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On account of the printers' strike in May 1921, all numbers of the JOURNAL from May 4, 1921, to date have been delayed. The dates of receipt in Washington of Numbers 9 to 20, inclusive, are given below:

No. 9. Due May 4, 1921.	Received May 23, 1921.
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No. 18. Due Nov. 4, 1921.	Received Nov. 17, 1921.
No. 19. Due Nov. 19, 1921.	Received Dec. 9, 1921.
No. 20. Due Dec. 4, 1921.	Received Dec. 15, 1921.

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Wednesday, January 19 The Society of Engineers, at the Cosmos Club.

Thursday, January 20 Joint meeting of the ACADEMY and the Chemical Society, at the Cosmos Club at 8 15 p m Program:

Address of the Retiring President of the ACADEMY C L ALSBERG *The relation of chemical structure to physiological action*

Saturday, January 22 The Biological Society, at the Cosmos Club

Wednesday, January 26 The Geological Society

Saturday, January 29 The Philosophical Society, at the Cosmos Club, at 8 15 p m Program

G BREIT *The distributed capacity of inductance coils*

J H DELLINGER and L J WHITTEMORE *Radio signal fading phenomena*

F B LITTELL *The variation of latitude and the constant of aberration from four years work with the photographic zenith tube at Washington*

Tuesday, February 1 The Botanical Society, at the Cosmos Club, at 8 00 p m

Wednesday, February 2 The Society of Engineers

Thursday, February 3 The Entomological Society

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday January 4 The Botanical Society at the Cosmos Club at 8 00 p m Program F LAMSON SCRIBNER *The flora of Rock Creek Park* J M SHULL *Skunk cabbage* Spathyema foetida

Thursday, January 6 The Entomological Society at the National Museum at 8 00 p m Program W R WALTON *Presidential address* R C SHANNON *Notes on classification of Syrphidae*

Saturday January 8 The Biological Society at the Cosmos Club at 8 00 p m Program L O HOWARD *Some views of the fight in southern France last summer against the Moroccan locust* S F BLAKE *Sexual difference in coloration of the spotted turtle*

Tuesday January 11 The Institute of Electrical Engineers at the Cosmos Club at 8 00 p m Program RALPH D MERSHON *Some things engineers should know concerning the rudiments of corporate financing*

Wednesday January 12 The Geological Society at the Cosmos Club at 8 00 p m Program H G FERGUSON *Lode deposits of Manhattan, Nevada* C N FENNER *Structural and volcanic geology of the Katmai region Alaska* H D MISER *Llanoria the Paleozoic land area in Louisiana and eastern Texas*

Thursday January 13 The Chemical Society at the Cosmos Club at 8 00 p m Program R C TOLMAN *The third law of thermodynamics*

Monday January 17 The Archaeological Society Program J A MONTGOMERY *Archaeological work in Palestine and the American School in Jerusalem*

[1] Notices received too late for publication before the date of the meeting

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PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, January 18. The Anthropological Society, at the National Museum, at 4.45 p.m. Program. WILLIAM E. MYER: *Recent explorations in the Cumberland Valley, Tennessee.*

Wednesday, January 19. The Society of Engineers, at the Cosmos Club, at 8.00 p.m. Program: H. M ALLBRIGHT: *Engineering problems in national parks.*

Saturday, January 22 The Biological Society, at the Cosmos Club, at 8.00 p m. Program: L. H. MILLER: *Asphalt beds of Rancho LaBrea.* H. C BRYANT *Birds and mammals of Yosemite National Park.*

Wednesday, January 26 The Geological Society, at the Cosmos Club, at 8.00 p.m. Program D. F. HEWETT and E V SHANNON: *Orientite, a new silicate of manganese and calcium.* CHARLES BUTTS: *General results of recent work on the Mississippian of the Mississippi and Ohio Valleys* J B REESIDE and H. BASSLER. *Phases of the Carboniferous and Triassic of southwestern Utah*

[1] Notices received too late for publication before the date of the meeting.

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Saturday, February 19. The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, February 23. The Geological Society, at the Cosmos Club, at 8 p m. Program

F E MATTHES: *Torrent channels and torrent levees in the Yosemite Valley.*
SIDNEY PAIGE: *Structure of the Homestake ore body*
G R MANSFIELD *Igneous geology of southeastern Idaho*

Thursday, February 24. The Chemical Society, at the Interior Department, at 8 p m

Saturday, February 26. The Philosophical Society, at the Cosmos Club, at 8 15 p m Program

C LEROY MEISINGER *The meteorological factor in aeronautics*
L H ADAMS and E D WILLIAMSON *The density of "strained" glass*
G T RUDE *The tidal work of the U S Coast and Geodetic Survey*

Tuesday, March 1. The Botanical Society

Wednesday, March 2 The Society of Engineers

Thursday, March 3 The Entomological Society

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, February 1 The Botanical Society, at the Cosmos Club, at 8 p m Program H L SHANTZ *Natural vegetation of Africa* IVAR TIDESTROM *Notes on the flora of the Iberian peninsula*

Wednesday, February 2 The Society of Engineers, at the Cosmos Club, at 8 15 p m Program T T CRAVEN *Naval aviation, the present situation and prospective future developments*

Thursday, February 3 The Entomological Society, at the National Museum, at 8 p m Program R. C SHANNON *Notes on classification of Syrphidae* E D BALL *Food plants and adaptation of tree hoppers* L O HOWARD *Extract from Fenton's review of Fabre's work*

Saturday, February 5 The Biological Society, at the Cosmos Club, at 8 p m Program IVAR TIDESTROM *Notes on the flora of the Iberian peninsula* R S BASSLER *Paleontological work at the National Museum*

Thursday, February 10 The Chemical Society, at the Cosmos Club, at 8 p m Program *Symposium on fertilizers* W D HURD *The present American fertilizer industry* F W BROWN *The potash situation* W H WAGGAMAN *Phosphates and phosphoric acid production* D P GAILLARD *Nitrogen resources, possibilities and requirements* O SCHREINER *Fertilizer utilization* R O E DAVIS *Concentrated chemical fertilizers*

Thursday, February 17 The ACADEMY, at the Cosmos Club, at 8 15 p m Program L O HOWARD *How the Government is fighting insects*

[1] Notices received too late for publication before the date of the meeting

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Original Papers

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, March 5. The Biological Society, at the Cosmos Club, at 8 p.m.

Tuesday, March 8. The Institute of Electrical Engineers, at the Cosmos Club, at 8 15 p.m.

Wednesday, March 9. The Geological Society, at the Cosmos Club, at 8 p.m. Program

DAVID WHITE *Presidential address*

Thursday, March 10 The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, March 12 The Philosophical Society, at the Cosmos Club, at 8 15 p.m.

Tuesday, March 15 The Anthropological Society, at the National Museum, at 4 45 p m.

Wednesday, March 16. The Society of Engineers, at the Cosmos Club.

Thursday, March 17. The ACADEMY, at the Cosmos Club, at 8.15 p.m. Program

A. M NICOLSON *The piezo-electric effect in crystals*

Saturday, March 19. The Philosophical Society, at the Cosmos Club, at 8 15 p.m.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, February 8 The Institute of Electrical Engineers, at the Cosmos Club, at 8 15 p.m Program HAROLD GOODWIN, JR · *The Superpower System and its relations to the Capital*

Tuesday, February 8 The Anthropological Society, at the National Museum, at 4 45 p m Program W E SAFFORD *Old and new Samoa.*

Wednesday, February 9 The Geological Society, at the Cosmos Club, at 8 p m Program H S. WASHINGTON *The Deccan traps and other plateau basalts* R C. WELLS *Utilization of some western salines and saline lakes* R S BASSLER *Paleontological work at the National Museum*

Tuesday, February 15 The Historical Society, at the Cosmos Club, at 8 15 p m Program CHARLES O PAULLIN: *The founding of an astronomical observatory in Washington*

Wednesday, February 16 The Society of Engineers, at the Cosmos Club, at 8 15 p m Program: CHARLES R MANN *Vocational education in the Army; its relation to the new military policy*

Saturday, February 19. The Biological Society, at the Cosmos Club, at 8 p m. Program C E MCCLUNG *Chromosomes in relation to heredity.* SEWALL WRIGHT *Heredity as a factor in the resistance of guinea pigs to tuberculosis.*

Saturday, February 26 The Philosophical Society, at the Cosmos Club, at 8.15 p m Program F HASTINGS SMYTH and HOWARD S ROBERTS *The system cupric oxide, cuprous oxide, oxygen* F WENNER, J. S. MARTIN, and NYNA L FORMAN· *The electrical resistance of the human body*

[1] Received too late for publication before the date of the meeting.

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, March 23. The Geological Society, at the Cosmos Club, at 8 p.m. Program.

L H ADAMS *The elastic properties of rocks.*

L LA FORGE *A suggested modification of the doctrine of peneplanation in the light of recent knowledge*

Thursday, March 24. The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, March 26 The Philosophical Society, at the Cosmos Club, at 8.15 p.m.

Saturday, April 2 The Biological Society, at the Cosmos Club.

Wednesday, April 6 The Society of Engineers.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL.[1]

Tuesday, March 1. The Botanical Society, at the Cosmos Club, at 8 p m Program HAVEN METCALF *The story of a plant introduction*

Tuesday, March 1 The Anthropological Society, at the National Museum, at 4 45 p.m Program: J WALTER FEWKES *The Fire Temple of the Cliff Dwellers*

Wednesday, March 2 The Society of Engineers, at the Cosmos Club, at 8 p m Program. WILLIAM MITCHELL *The development of an air force as a national asset*

Thursday, March 3 The Entomological Society, at the National Museum, at 8 p m. Program: R E SNODGRASS *Life history of the ribbed cocoon maker and the resplendent shield-bearer of the apple.*

Saturday, March 5 The Biological Society, at the Cosmos Club, at 8 p m Program. H M HALL *The synthetic method of botanical taxonomy.*

Thursday, March 10 The Chemical Society, at the Cosmos Club, at 8 p m Program E. T. WHERRY *Chemical crystallography* R W G WYCKOFF *X-rays and crystal structure.*

Saturday, March 12 The Philosophical Society, at the Cosmos Club, at 8 15 p m Program. T S SLIGH, JR *Recent modifications in resistance thermometer construction.* R M WILHELM and AMELIA K. BENSON *A comparison of the International Hydrogen Scale with the standard scale of temperature defined by the platinum resistance thermometer* C O FAIRCHILD *New methods of sealing optical glass*

[1] Received too late for publication before the date of the meeting.

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MEETINGS OF NATIONAL ORGANIZATIONS IN WASHINGTON

April 18-20. The American Geophysical Union.
April 20-21. The American Meteorological Society.
April 22-23. The American Physical Society.
April 25-27. The National Academy of Sciences.
May 2-4. The American Society of Mammalogists.

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, April 5. The Botanical Society, at the Cosmos Club, at 8 p.m.

Wednesday, April 6. The Society of Engineers.

Thursday, April 7. The Entomological Society, at the National Museum, at 8 p m

Saturday, April 9. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program

L. H ADAMS. *The heating of substances by expansion*
W P. WHITE· *Specific and latent heats of nickel and monel metal.*
C. H. MEYERS and E F MUELLER *Mollier diagrams.*

Tuesday, April 12. The Institute of Electrical Engineers.

Wednesday, April 13. The Geological Society, at the Cosmos Club, 8 p.m. Program.

G O SMITH *Scientific by-products of applied geology*
DAVID WHITE: *The structure of oil shales* (Presidential address)

Thursday, April 14. The Chemical Society, at the Cosmos Club.

Saturday, April 16. The Biological Society, at the Cosmos Club.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, March 8 The Institute of Electrical Engineers, at the Cosmos Club, at 8 15 p m Program P A MEYER *Industrial electric heating*

Wednesday, March 9 The Geological Society, at the Cosmos Club, at 8 p m Program: G R MANSFIELD· *Igneous geology of southeastern Idaho.* A. I. JONAS and E. BLISS KNOPF. *Stratigraphy of the metamorphic rocks of southeastern Pennsylvania and Maryland* O E MEINZER *A map of Pleistocene lakes in the Basin-and-Range Province and its interpretation*

Wednesday, March 16 The Society of Engineers, at the Cosmos Club. at 8 15 p m. Program JOHN S CONWAY. *Radio fog signals*

Saturday, March 19 The Biological Society, at the Cosmos Club, at 8 p.m. Program: F. H KNOWLTON *Flora of some newly discovered lake beds of southern Colorado.* H C OBERHOLSER. *The breeding water fowl of the Great Plains region*

Tuesday, March 22 The Anthropological Society, at the National Museum, at 4 45 p m Program. G N COLLINS *Origin and early distribution of maize.*

Thursday, March 24 The Society of Foresters, at the Cosmos Club, at 8 p m. Program: R S KELLOGG *The pulp-wood supply and the paper industry.*

Friday, March 25. The Chemical Society, at the Interior Department, at 8 p.m. Program. C R. DE LONG· *Chemical industry from the tariff standpoint,* F L. HESS: *The tariff on certain minerals used in chemical industries,*

Saturday, Mach 26 The Philosophical Society, at the Cosmos Club, at 8 15 p m. Program O S. ADAMS. *Authalic latitude, a cartographic expedient.* E. A. ECKHARDT and J C. KARCHER *A chronographic recorder of radio time signals.*

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ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, April 20. The Society of Engineers, at the Cosmos Club, at 8.15 p.m.

Thursday, April 21. The ACADEMY, at the Cosmos Club, at 8.15 p.m.

Saturday, April 23. (The regular meeting of the Philosophical Society is postponed on account of the meeting of the American Physical Society on the same date.)

Wednesday, April 27. The Geological Society, at the Cosmos Club, at 8 p.m. Program:

M. AUROUSSEAU: A short account of the structural geology of Australia.

R. A. DALY: The nature of the forces involved in mountain building.

Thursday, April 28. The Chemical Society.

Saturday, April 30. The Biological Society, at the Cosmos Club, at 8 p.m.

Tuesday, May 3. The Botanical Society, at the Cosmos Club, at 8 p.m.

MEETINGS OF NATIONAL ORGANIZATIONS IN WASHINGTON

April 18–20. The American Geophysical Union.

April 20–21. The American Meteorological Society.

April 22–23. The American Physical Society.

April 25–27. The National Academy of Sciences.

May 2–4. The American Society of Mammalogists.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Saturday, April 2. Joint meeting of the ACADEMY and the Biological Society, at the Cosmos Club at 8.15 p.m. Program: A. D. HOPKINS: *Intercontinental problems in natural and artificial distribution of plants and animals.*

Tuesday, April 5. Joint meeting of the Anthropological Society and the Medical Society, at the Medical Society Building, at 8 p.m. Program: GEORGE M. KOBER: *A plea for the prevention of permanent disabilities in childhood.*

Tuesday, April 5. The Botanical Society, at the Cosmos Club, at 8 p.m. Program: W. H. WESTON: *Following a fungus through the Philippines.* J. F. CLEVENGER: *On Zamia integrifolia Chapm. and its starch, Florida arrow root.* ARNO VIEHOEVER: *Edible and poisonous beans of the Lima type,* Phaseolus lunatus.

Wednesday, April 6. Joint meeting of the Washington Society of Engineers and the Washington Section of the American Institute of Mining and Metallurgical Engineers. Program: GEO. S. RICE: *Destruction of French mines and methods used in their rehabilitation.*

Thursday, April 7. The Entomological Society, at the National Museum. Program: AUGUST BUSCK and CARL HEINRICH: *On the male genitalia of the Microlepidoptera and their systematic importance.* S. A. ROHWER: *Injurious and beneficial cynipid galls.*

[1] Received too late for publication before the date of the meeting.

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Thursday, May 5. The Entomological Society, at the National Museum, at 8 p.m.

Saturday, May 7. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

I C. Gardner: *Self-contained range finders and their errors.*
I. G. Priest *Spectral distribution required to evoke the gray sensation.*

Tuesday, May 10. The Institute of Electrical Engineers, at the Cosmos Club.

Wednesday, May 11. The Geological Society, at the Cosmos Club, at 8 p.m. Program:

B L Johnson: *The glacial launching of the Ft Liscum landslide, Alaska.*
W. F. Foshag *Origin of the colemanite deposits of California*
E. T. Wherry *Relations of vegetation to geological formation*

Thursday, May 12. The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, May 14. The Biological Society, at the Cosmos Club.

Thursday, May 19. The Academy, at the Cosmos Club.

OTHER ANNOUNCEMENTS

Saturday, May 7. The Maryland-Virginia-District of Columbia Section of the Mathematical Association of America, at the drafting hall of the Capitol, S. Capitol and B Streets SE, at 11 a.m. and 2 p m.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, April 12 The Institute of Electrical Engineers, at the Cosmos Club, at 8.15 p m Program J. Lester Woodbridge. *Storage batteries; their characteristics and applications*

Thursday, April 14 The Chemical Society, at the Cosmos Club, at 8 p m Program. Edgar F. Smith: *A glance at the early organic chemistry of the United States.*

Saturday, April 16 The Biological Society, at the Cosmos Club, at 8 p m Program: E. W Nelson: *Alaska and the reindeer industry.* F C. Lincoln. *The Fall migration of ducks from Lake Scugog, Ontario*

Tuesday, April 19 The Anthropological Society, at the National Museum, at 4 45 p.m. Program. C Hart Merriam: *The Indians of the Yosemite region, California.* Annual meeting and election of officers

Wednesday, April 20. The Society of Engineers, at the Cosmos Club, at 8.15 p m. Program: L. W Wallace *The Federated American Engineering Societies.* John L. Harper. *Niagara Falls and its utilization*

Thursday, April 21. The Academy, at the Cosmos Club, at 8 15 p.m. Program: C. G. Abbot. *The solar constant observing stations of the Smithsonian Institution.*

[1] Received too late for publication before the date of the meeting.

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Saturday, May 21. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

H. A. MARMER: *Relation of coastal currents and winds on the Pacific Coast.*

S. J. MAUCHLY: *New results concerning the diurnal variation of atmospheric electricity.*

L. A. BAUER: *New relations between terrestrial magnetism, terrestrial electricity, and solar activity.*

Thursday, June 2. The Entomological Society, at the National Museum, at 8 p.m. Program:

Notes and exhibition of specimens.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Saturday, April 30. The Biological Society, at the Cosmos Club, at 8 p.m. Program: J. N. ROSE: *Discovery of a remarkable cactus from Haiti.* JOSEPH GRINNELL: *The principle of rapid peering in birds.* T. S. PALMER: *Notes on some parrots imported into the United States.* E. A. GOLDMAN: *Rats in the War Zone.*

Tuesday, May 3. The Botanical Society, at the Cosmos Club, at 8 p.m. Program: ARNO VIEHOEVER: *Edible and poisonous beans of the lima type.* C. DWIGHT MARSH: *Poisonous whorled milkweeds.* PETER BISSET: *Roses for garden decoration.*

Thursday, May 5. The Entomological Society, at the National Museum, at 8 p.m. Program: A. B. GAHAN: *Phytophagous Chalcididae.* Notes and exhibition of specimens.

Tuesday, May 10. The Institute of Electrical Engineers, at the Cosmos Club, at 8.15 p.m. Program: Moving pictures illustrating the production and use of X-rays. Moving pictures of the lumber industry. Annual elections.

Thursday, May 12. The Chemical Society, at the Cosmos Club, at 8 p.m. Program: Symposium on optical methods as applied to chemical investigations. W. F. MEGGERS: *Quantitative spectrum analysis.* W. T. MATHEWSON: *Estimation of colorless substances by spectro-photometric methods.* I. G. PRIEST: *A direct reading spectro-photometer for measuring the transmissivity of liquids.* FREDERICK BATES: *Polarimetry.* F. E. WRIGHT: *Crystal optics in chemistry.*

Saturday, May 14. The Biological Society, at the Cosmos Club, at 8 p.m. Program: F. G. ASHBROOK: *Recent notes on the fur trade in the United States.* S. A. ROHWER: *Injurious and beneficial insect galls.*

Tuesday, May 17. The Geological Society, at the Interior Department, at 8 p.m. Program: EMIL S. FISCHER: *Economic investigations in China.*

[1] Received too late for publication before the date of the meeting.

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NOTE

The May and June numbers of the Journal have been delayed on account of strikes in the printing trades.

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NOTE

The May, June and July numbers of the JOURNAL have been delayed on account of strikes in the printing trades.

ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Monday, June 27. The Botanical Society, at the Cosmos Club at 8 P.M. Program: J. F. ROCK: *A trip through North Siam, Burma and Assam for the Office of Foreign Seed and Plant Introduction.*

[1] Received too late for publication before the date of the meeting.

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NOTE

The July and August numbers of the Journal have been delayed on account of strikes in the printing trades

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The ACADEMY has on hand a miscellaneous stock of separates of papers from the *Proceedings* (1898–1911). By authority of the Board of Managers, these papers are offered for sale for a limited period at the reduced prices indicated below. (Publication of these classified lists was begun on March 4 and will be continued in subsequent numbers of the JOURNAL.)

ENTOMOLOGY

ENTOMOLOGICAL RESULTS FROM THE HARRIMAN ALASKA EXPEDITION

(1) VII * KINCAID, TREVOR. The Tenthredinoidea. 26 pp.	$0 05
(2) VIII. KINCAID, TREVOR. The metamorphoses of some Alaska Coleoptera. 22 pp., 5 pls.	0 10
(3) IX. COQUILLETT, D. W. Diptera. 76 pp.	0 10
(4) X. BANKS, NATHAN. Neuropteroid insects. 12 pp., 2 pls.	0 05
(5) XI. BANKS, NATHAN. Arachnida. 10 pp., 1 pl.	0 05
(6) XII. DYAR, HARRISON G. Lepidoptera. 16 pp.	0 05
(7) XIII. HEIDEMANN, O. Heteroptera. 4 pp.	0 05
(8) XIV. KINCAID, TREVOR. The Sphegoidea and Vespoidea. 4 pp.	0 05
(9) XV. CAUDELL, A. N. Orthoptera. 2 pp.	0 05
(10) XVI. PERGANDE, THEO. Aphididae. 6 pp.	0 05
(11) XVII. PERGANDE, THEO. Formicidae. 4 pp.	0 05
(12) XVIII. SCHWARZ, E. A. Coleoptera. 16 pp.	0 05
(13) XIX. SCHWARZ, E. A. Psyllidae. 2 pp.	0 05
(14) XXII. CURRIE, ROLLA P. Odonata. 7 pp.	0 05
(15) XXVII. FOLSOM, JUSTUS WATSON. Apterygota. 30 pp., 5 pls.	0 10
(16) XXVIII. ASHMEAD, WILLIAM HARRIS. Hymenoptera. 158 pp., 3 pls.	0 25

ENTOMOLOGICAL RESULTS FROM THE HOPKINS-STANFORD GALAPAGOS EXPEDITION

(1) I.** HEIDEMANN, O. Hemiptera. 8 pp.	0 05
(2) II. COQUILLETT, D. W. Diptera. 10 pp.	0 05
(3) III. CURRIE, ROLLA P. Odonata. 10 pp.	0 05
(4) IV. MCNEILL, JEROME. Orthoptera. 20 pp.	0 05
(5) V. BANKS, NATHAN. Thysanura and Termitidae. 6 pp.	0 05
(6) VII. BANKS, NATHAN. Arachnida. 38 pp., 3 pls.	0 10
(7) IX. SNODGRASS, R. E. Schistocera, Sphingonotus, and Halmenus. 46 pp., 2 pls.	0.15
(8) X. KELLOGG, VERNON L., and KUWANA, S. I. Mallophaga from birds. 43 pp., 4 pls.	0 15

OTHER ENTOMOLOGICAL PAPERS

CASEY, THOMAS L. A revision of the American components of the Tenebrionid subfamily Tentyriinae. 248 pp.	0 25
CASEY, THOMAS L. A revision of the Tenebrionid subfamily Coniontinae. 116 pp.	0 20
CASEY, THOMAS L. Studies in the American Buprestidae. 132 pp.	0 20
HOWARD, L. O. A contribution to the study of the insect fauna of human excrement, with special reference to the spread of typhoid fever by flies. 64 pp., 2 pls.	0.15
KELLOGG, VERNON L., and BELL, RUBY G. Studies of variation in insects. 180 pp.	0.25
SHAFER, GEORGE DANIEL. Histology and development of the divided eyes of certain insects. 28 pp., 5 pls.	0.10

The set of 16 Harriman papers, $1 00; the set of 8 Hopkins-Stanford papers, $0.50; the set of 6 miscellaneous papers, $1.00. The entire set of 30 entomological papers, $2.50.

This page may be used as an order blank. Send orders with check or stamps to the Corresponding Secretary, ROBERT B. SOSMAN, Geophysical Laboratory, Washington, D. C.

* Number of the paper in the Harriman Alaska series

**Number of paper in the Hopkins-Stanford series

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, October 4. The Botanical Society, at the Cosmos Club at 8 p. m. Program:

W. A. ORTON: *The Dahlia: group classification, climatic requirements, and aims of breeders.*
J. B. S. NORTON: *The Dahlia: varieties and history.*
W. E. SAFFORD: *The Dahlia: botany and chemistry.*

Thursday, October 6. The Entomological Society.

OFFICERS OF THE ACADEMY

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, October 5. The Society of Engineers, at the Cosmos Club, at 8:15 p.m. Program.

JOHN MURPHY: *Ice formation and prevention, with special reference to frazil and anchor ice*

Thursday, October 6. The Entomological Society, at the National Museum at 8 p.m. Program.

J. N. ALDRICH: *Insect collecting in Alaska.* Notes and exhibition of specimens.

Saturday, October 8. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

H. S. ROBERTS, 3D: *A furnace temperature regulator.*

H. N. EATON: *Aerial navigation*

Tuesday, October 11. The Institute of Electrical Engineers, at the Cosmos Club, at 8.15 p.m. Program:

J. E. WHITTEMORE: *Principles of the radio direction finder, and its application to marine navigation*

Thursday, October 13. The Chemical Society, at the Cosmos Club, at 8 p.m. Program:

E. E. SLOSSON: *The constructive chemist.*

Reports from the New York meeting of the American Chemical Society

Saturday, October 15. The Biological Society.

OTHER ANNOUNCEMENTS

The Physics Club of the Bureau of Standards:

Monday, October 17, at 4:30 p.m. Program:

ARTHUR L. DAY: *The study of California earth movements*

Monday, October 24, at 4:30 p.m. Program:

H. G. GALE: *Earth tides.*

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The Academy has on hand a miscellaneous stock of separates of papers from the *Proceedings* (1898 1911). By authority of the Board of Managers, these papers are offered for sale for a limited period at the reduced prices indicated below. (Publication of these classified lists was begun on March 4 and will be continued in subsequent numbers of the Journal)

ZOOLOGY

(See also lists in other numbers of the Journal, covering general biology, entomology, ichthyology, ornithology, and mammalogy)

Andrews, E A. The sperm receptacle in the Crayfishes, Cambarus cubensis and C paradoxus 19 pp	$0 05
Bolkay, Stefan On the systematic value of Rana chinensis Osbeck 17 pp, 1 pl	0 05
Dall, William Healey Linnaeus as a zoologist 3 pp	0 05
Eigenmann, Carl H The eyes of Rhineura floridana 16 pp, 3 pls	0 05
Fisher, Walter K New Starfishes from the Pacific coast of North America 29 pp	0 10
Ortmann, A E Mexican, Central American, and Cuban Cambari 21 pp	0 10
Starks, Edwin Chapin Synonymy of the fish skeleton 34 pp, 3 pls	0 10

Zoological Papers from the Harriman Alaska Expedition

II.	Ritter, Wm E Harrimania maculosa, a new genus and species of Enteropneusta from Alaska, with special regard to the character of its notochord 22 pp	0 05
III.	Ritter, Wm E and Crocker, Gulielma R Multiplication of rays and bilateral symmetry in the 20-rayed Star-fish, Pycnopodia helianthoides (Stimpson) 28 pp, 2 pls.	0 10
VI	Robertson, Alice The Bryozoa 26 pp, 3 pls	0 10
XX	Coe, Wesley R The Nemertians 110 pp, 13 pls	0 20
XXI	Nutting, C C The Hydroids 60 pp, 13 pls	0 15
XXIII	Ritter, Wm E The Ascidians 42 pp, 4 pls	0 10
XXX	Torrey, Harry Beal Anemones, with discussion of variation in Metridium 38 pp, 2 pls	0 10

Zoological Papers from the Hopkins-Stanford Galapagos Expedition, 1898–1899

VI	Richardson, Harriet The Isopods 4 pp	0 05
VIII	Rathbun, Mary J Brachyura and Macrura 18 pp, 1 pl	0 05
XII	Clark, Hubert Lyman Echinodermata 12 pp	0 05
XIII	Pilsbry, H. A, and Vanatta, E G Marine Mollusca 12 pp, 1 pl	0 05
XIV.	Heller, Edmund Reptiles 60 pp	0 15

Zoological Papers from the Branner Agassiz Expedition to Brazil

I	Rathbun, Mary J The Decapod and Stomatopod Crustacea. 24 pp	0 05
II	Richardson, Harriet The Isopod Crustacea 4 pp	0 05
V	Dall, William Healey Mollusks from the vicinity of Pernambuco 9 pp	0 05
	The set of 22 zoological papers	1.50

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Wednesday, October 19. The Society of Engineers, at The Cosmos Club, at 8.15 p.m. Program:

WILLIAM BOWIE: *The work of the Coast and Geodetic Survey in relation to engineering activities*

Thursday, October 20. The ACADEMY, at the Public Library, at 8.15 p.m. Program:

Discussion and inspection of the ACADEMY'S *One hundred popular books in science*, and of books proposed for a list of information-manuals

Saturday, October 22. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

H. H. KIMBALL: *Sky brightness and daylight illumination measurements*

D. R. HARPER, 3D: *The mathematical equations for heat conduction in the fins of air-cooled engines*

Tuesday, October 25. The Chemical Society, at the National Museum, at 8.15 p.m. Program:

Presentation of a portrait of JOSEPH PRIESTLEY, the discoverer of oxygen, to the National Museum

EDGAR F. SMITH: *Some remarks on the history of chemistry in the United States*

F. W. CLARKE: *The organization meeting of the American Chemical Society at the home of Priestley.*

Wednesday, October 26. The Geological Society, at the Cosmos Club, at 8 p.m. Program:

J. B. EBY: *Structural geology of Wise County, Virginia*

G. R. MANSFIELD: *Structure of the Teton Coal Field, Idaho.*

H. S. WASHINGTON: *The granites of Washington, D. C.*

Saturday, October 29. The Biological Society.

Tuesday, November 1. The Botanical Society.

Wednesday, November 2. The Society of Engineers.

Thursday, November 3. The Entomological Society.

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Saturday, November 5. The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

H A MARMER. *The great tides in the Bay of Fundy, and their causes.*

F. L. MOHLER and P. D FOOTE *Characteristic soft X-rays*

Tuesday, November 8. The Institute of Electrical Engineers.

Wednesday, November 9. The Geological Society, at the Cosmos Club, at 8 p.m. Program

O. E MEINZER *An outline of hydrology*

F. E MATTHES *Gilbert's theory of the mechanics of exfoliation.*

Thursday, November 10. The Chemical Society. Program:

Annual reports and election of officers.

Five-minute informal communications

Saturday, November 12. Joint meeting of the ACADEMY, the Botanical Society, and the Biological Society at the Cosmos Club, at 8 p.m. Program;

ARTHUR DE JACZEWSKI *The development of mycology and pathology in Russia.*

NICHOLAS I VAVILOV *Russian work in genetics and plant breeding*

VERNON KELLOGG *The interrelations of Russian and American scientists.*

Wednesday, November 16. The Society of Engineers.

Thursday, November 17 The ACADEMY, at the Cosmos Club, at 8 15 p m. Program·

H D CURTIS *The Sun, our nearest star.*

Saturday, November 19. The Philosophical Society, at the Cosmos Club, at 8 15 p.m.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Tuesday, October 25 The Anthropological Society, at the National Museum, at 4 45 p m Program FRANCES DENSMORE. *Some recent developments in the study of American Indian music*

Saturday, October 29 The Biological Society, at the Cosmos Club, at 8 p m Program R S BASSLER *Sex characters in fossils.* W E SAFFORD *The dahlia, its origin and development.*

[1] Received too late for publication before the date of the meeting.

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BIOLOGY, GENERAL

COOK, O F. The vital fabric of descent 23 pp	$0 10
COOK, O F Aspects of kinetic evolution 207 pp	0 40
COOK, O F. Origin and evolution of angiosperms through apospory. 20 pp	0 05
COOK, O F Mendelism and other methods of descent. 52 pp	0 15
DAVENPORT, CHARLES B Heredity and Mendel's Law. 19 pp	0 10
GREENE, EDWARD L. Linnaean memorial address 34 pp	0 10
GREENE, EDWARD L Linnaeus as an evolutionist. 10 pp	0 05
The set of 7 biological papers	0.75

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ANNOUNCEMENTS OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Tuesday, December 6. The Botanical Society, at the Cosmos Club, at 8 p.m. Program:

WILSON POPENOE. *Hunting new plants for American horticulture in the highlands of Central and South America.*

L. C. C. KRIEGER: *A sketch of the history of mycological illustrations (higher Fungi).*

Tuesday, December 6. The Anthropological Society, at the National Museum, at 4:45 p.m. Program:

ALEŠ HRDLIČKA: *How the earth was peopled.*

Wednesday, December 7. The Society of Engineers

Thursday, December 8. The Chemical Society.

Saturday, December 10. The Biological Society.

Tuesday, December 13. The Institute of Electrical Engineers.

Wednesday, December 14. The Geological Society, at the Cosmos Club, at 8 p.m.

Thursday, December 15. The ACADEMY, at the Cosmos Club, at 8 15 p m. Program

WM. E. SAFFORD: *The food plants of America.*

Saturday, December 17. The Philosophical Society, at the Cosmos Club, at 8:15 p.m.

OTHER ANNOUNCEMENTS

Friday, December 16, at 3·30 p m., a public lecture at the Bureau of Standards: Prof CAVALIER *Les industries chimiques en France pendant la Guerre.*

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Wednesday, November 9. The Geological Society, at the Cosmos Club, at 8 p m. Program. PENTTI ESKOLA *Metamorphic limestone as a geological thermometer.* O. E. MEINZER · *An outline of hydrology*

Wednesday, November 16 The Society of Engineers, at the Cosmos Club, at 8·15 p m Program THOMAS RIGGS, JR *The problems of Alaska*

Thursday, December 1. The Entomological Society, at the National Museum, at 8 p m. Program: Election of officers S HADWEN *On Oestridae.*

[1] Received too late for publication before the date of the meeting

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Tuesday, December 20. The Anthropological Society, at the National Museum, at 4:45 p.m. Program:

J WALTER FEWKES: *Lost Indians of the Willows.*

Wednesday, December 21. The Society of Engineers, at the Cosmos Club, at 8:15 p.m. Program:

L. O. ARMSTRONG: *The Lure of the North.*
Annual reports and elections.

Tuesday, January 3. The Botanical Society, at the Cosmos Club, at 8:15 p.m.

Wednesday, January 4. The Society of Engineers.

Thursday, January 5. The Entomological Society.

Saturday, January 7. The Biological Society, at the Cosmos Club, at 8 p.m.

Tuesday, January 10. The ACADEMY, at the Carnegie Institution, at 8:15 p.m. Program:

A. H BROOKS Presidential Address.
Annual reports and elections.

Thursday, January 12 The Chemical Society, at the Cosmos Club, at 8 p m. Program

WM BLUM· Presidential Address· *Researches on the electro-deposition of metals.*

OTHER ANNOUNCEMENTS

Thursday to Saturday, December 29–31 The Association of American Geographers, at the National Geographic Society's building, 16th and M streets.

PROGRAMS ANNOUNCED SINCE THE PRECEDING ISSUE OF THE JOURNAL[1]

Thursday, December 8 The Chemical Society, at the Cosmos Club, at 8 p m. Program: R. B. MOORE. *Radium, its properties and manufacture* Miss A H ARMSTRONG: *The testing of radium products.* HOWARD A. KELLY. *The therapeutic use of radium*

Saturday, December 10 The Biological Society, at the Cosmos Club, at 8 p m. Program. Brief notes and exhibition of specimens. Annual reports and elections.

Tuesday, December 13. The Institute of Electrical Engineers, at the Cosmos Club, at 8 p m. Program· J. W. HACKETT. *The manufacture of electric cable.*

Wednesday, December 14 The Geological Society, at the Cosmos Club, at 8 p.m. Program: G W STOSE (Presidential Address)· *Relation of faults to folds in the Appalachians* Annual reports and elections

Saturday, December 17. The Philosophical Society, at the Cosmos Club, at 8·15 p.m. Program. W W COBLENTZ: *The effective temperature of the stars as estimated from the energy distribution in the complete spectrum.* P. D. FOOTE, F. L. MOHLER, and W. F. MEGGERS. *A significant exception to the principle of selection.* W. P. WHITE: *Some precision pendulum-driving apparatus.*

[1] Received too late for publication before the date of the meeting.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. 11 JANUARY 4, 1921 No. 1

MINERALOGY.—*A new classification of the sulfo-salt minerals.*
EDGAR T. WHERRY and WILLIAM F. FOSHAG, National Museum.[1]

The data for this paper were collected while the senior author was employed in the National Museum; the junior author, his successor there, has aided in bringing them up to date The plan followed is essentially the same as that recently applied to the sulfide minerals,[2] although formulas are stated in both expanded and condensed forms, to bring out relationships as fully as possible. The chief new features are the systematic assignment of minerals to divisions based on the ratios of basic and acidic sulfides, and to groups based on crystallization, the classing of minerals containing both univalent and bivalent metals as double compounds rather than as isomorphous mixtures, and the throwing out of evident admixtures before calculating formulas from analyses; and the interpretation of certain instances of high sulfur content as due to a higher state of oxidation of the metal rather than the non-metal, resulting in the discarding of a "sulfarsenate-sulfantimonate" division, such as has usually been recognized heretofore.

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received November 12, 1920.

[2] This JOURNAL, 10: 487 1920.

SULFO-SALTS METALLIC SALTS OF SEMI-METAL SULFO-ACIDS (Also SELENO-ACIDS)

1 3 DIVISION			New
VRBAITE GROUP ORTHORHOMBIC			New
Eichbergite	$Cu_2S \cdot 3(Bi,Sb)_2S_3$	$Cu(Bi,Sb)_3S_5$	Crystallization and homogeneity uncertain
Vrbaite	$Tl_2S \cdot 3(As,Sb)_2S_3$	$Tl(As,Sb)_3S_5$	
1 2 DIVISION			Part of Dana s Acidic division
LIVINGSTONITE GROUP CRYSTALLIZATION UNKNOWN			New
Livingstonite	$HgS \cdot 2Sb_2S_3$	$HgSb_4S_7$	Homogeneity uncertain yet shows distinctive mineragraphic characters Davy and Farnham *Micr exam ore min* N Y 1920
Chiviatite	$PbS \cdot 2Bi_2S_3$	$PbBi_4S_7$	Often assigned a more complex formula but after deducting impurities the analyses agree with that adopted the theory for which is Pb 16 4 Bi 65 8 S 17 8%
1 1 5 OR 2 3 DIVISION			Part of Dana s Acidic division
REZBANYITE GROUP CRYSTALLIZATION UNKNOWN			New Histrixite if homogeneous belongs here
Rezbanyite	$2PbS \cdot 3Bi_2S_3$	$Pb_2Bi_6S_{11}$	Homogeneity uncertain yet shows distinctive mineragraphic characters (D & F) corrected analyses agree with formula adopted theory Pb 20 6 Bi 61 9 S 17 5%
1 1 17 OR 6 7 DIVISION			New
CYLINDRITE GROUP STRUCTURE CYLINDRICAL			New
Cylindrite	$6PbS \cdot 6SnS_2 \cdot Sb_2S_3$	$Pb_6Sn_6Sb_2S_{21}$	
1 1 DIVISION			Dana s Meta-division
TRECHMANNITE GROUP HEXAGONAL TRIGONAL TETARTOHEDRAL			New
Trechmannite	$Ag_2S \cdot As_2S_3$	$AgAsS_2$	
Platynite	$PbS \cdot Bi_2Se_3$	$PbBi_2SSe_3$	

CHALCOSTIBITE GROUP ORTHORHOMBIC			Dana's Zinkenite group
Chalcostibite	$Cu_2S \cdot Sb_2S_3$	$CuSbS_2$	Includes guejarite (Dana No 110) compare Dana App I p 16
Emplectite	$Cu_2S \cdot Bi_2S_3$	$CuBiS_2$	Includes cuprobismutite (Dana No 112) the analyses and properties of the two being essentially identical
Andorite	$Ag_2S \cdot 2PbS \cdot 3Sb_2S_3$	$AgPb(SbS_2)_3$	Homogeneity has been questioned but the evidence for its definiteness seems adequate
Hutchinsonite	$Tl_2S \cdot PbS \cdot 2As_2S_3$	$Tl_2Pb(AsS_2)_4$	The name sartorite used by Dana is later ending ite added for uniformity
Sclerоclasite	$PbS \cdot As_2S_3$	$Pb(AsS_2)$	
Zinkenite	$PbS \cdot Sb_2S_3$	$Pb(SbS_2)_2$	Also spelled zinckenite
MIARGYRITE GROUP MONOCLINIC			Separated but not named by Dana
Smithite	$Ag_2S \cdot As_2S_3$	$AgAsS_2$	
Miargyrite	$Ag_2S \cdot Sb_2S_3$	$AgSbS_2$	
Plenargyrite	$Ag_2S \cdot Bi_2S_3$	$AgBiS_2$	
Lorandite	$Tl_2S \cdot As_2S_3$	$TlAsS_2$	
GROUP OF UNKNOWN CRYSTALLIZATION			New
Matildite	$Ag_2S \cdot Bi_2S_3$	$AgBiS_2$	
Alaskaite	$Ag_2S \cdot PbS \cdot 2Bi_2S_3$	$Ag_2Pb(BiS_2)_4$	Homogeneity uncertain
Galenobismutite	$PbS \cdot Bi_2S_3$	$Pb(BiS_2)_2$	
Weibullite	$2PbS \cdot Bi_2S_3 \cdot Bi_2Se_3$	$Pb_2Bi_4S_5Se_3$	
Berthierite	$FeS \cdot Sb_2S_3$	$Fe(SbS_2)$	
1:2.5 1 OR 5:4 DIVISION			Part of Dana's Intermediate division
PLAGIONITE GROUP MONOCLINIC			Separated but not named by Dana
Liveingite	$5PbS \cdot 4As_2S_3$	$Pb_5As_8S_{17}$	
Plagionite	$5PbS \cdot 4Sb_2S_3$	$Pb_5Sb_8S_{17}$	
Bismutoplagionite	$5PbS \cdot 4Bi_2S_3$	$Pb_5Bi_8S_{17}$	Crystallization possibly orthorhombic
1:3.3 1 OR 4:3 DIVISION			New
BAUMHAUERITE GROUP MONOCLINIC			New
Baumhauerite	$4PbS \cdot 3As_2S_3$	$Pb_4As_6S_{13}$	

1.5 = 1 OR 3 : 2 DIVISION			
KLAPROTHOLITE GROUP ORTHORHOMBIC			
Klaprotholite	$3Cu_2S.2Bi_2S_3$	$Cu_6Bi_4S_9$	Part of Dana's Intermediate division
Schirmerite	$2Ag_2S.PbS.2Bi_2S_3$	$Ag_2PbBi_4S_8$	Separated but not named by Dana
Rathite	$3PbS.2As_2S_3$	$Pb_3As_4S_9$	Crystallization and homogeneity uncertain
1.67 = 1 OR 5 : 3 DIVISION			
JAMESONITE GROUP ORTHORHOMBIC OR MONOCLINIC			New
			New
Jamesonite	$4PbS.FeS.3Sb_2S_3$	$Pb_4FeSb_6S_{14}$	Includes warrenite (Dana No 128) the old formulas $3PbS.2Sb_2S_3$ and $2PbS.Sb_2S_3$ have been discredited Schaller's formula is adopted
Franckeite	$5PbS.2SnS_2.Sb_2S_3$	$Pb_5Sn_2Sb_2S_{12}$	Includes plumbostannite
1.75 = 1 OR 7 : 4 DIVISION			New may belong with preceding
HETEROMORPHITE GROUP MONOCLINIC			New
Heteromorphite	$7PbS.4Sb_2S_3$	$Pb_7Sb_8S_{19}$	Pisani's formula is adopted
2 : 1 DIVISION			Part of Dana's Intermediate division
DUFRENOYSITE GROUP ORTHORHOMBIC			Dana's Jamesonite group
Silver-jamesonite	$2Ag_2S.8PbS.5Sb_2S_3$	$Ag_4Pb_8Sb_{10}S_{25}$	Shannon *Proc U S Nat Mus* 58 601 1920
Dufrenoysite	$2PbS.As_2S_3$	$Pb_2As_2S_5$	
Plumosite	$2PbS.Sb_2S_3$	$Pb_2Sb_2S_5$	
Cosalite	$2PbS.Bi_2S_3$	$Pb_2Bi_2S_5$	Includes kobellite (Dana No 131) which is an isomorphous mixture of this and the preceding
GROUP OF UNKNOWN CRYSTALLIZATION			New
Brongniardite	$Ag_2S.PbS.Sb_2S_3$	$Ag_2PbSb_2S_5$	Described as isometric through error, homogeneity uncertain yet shows distinctive mineragraphic characters (D & F)
Schapbachite	$Ag_2S.PbS.Bi_2S_3$	$Ag_2PbBi_2S_5$	Homogeneity uncertain
2.25 = 1 OR 9 : 4 DIVISION			Part of Dana's Intermediate division
SEMSEYITE GROUP MONOCLINIC			Separated but not named by Dana
Semseyite	$9PbS.4Sb_2S_3$	$Pb_9Sb_8S_{21}$	Spencer's simplest formula is adopted

2 33 1 OR 7 3 DIVISION			
DIAPHORITE GROUP ORTHORHOMBIC			
Diaphorite	$3Ag_2S.4PbS.3Sb_2S_3$	$Ag_3Pb_2Sb_3S_8$	Part of Dana s Intermediate division Separated but not named by Dana
FREIESLEBENITE GROUP MONOCLINIC			
Freieslebenite	$3Ag_2S.4PbS.3Sb_2S_3$	$Ag_3Pb_2Sb_3S_8$	Separated but not named by Dana
2 5 1 OR 5 2 DIVISION			
BOULANGERITE GROUP CRYSTALLIZATION ORTHORHOMBIC			Part of Dana s Intermediate division New
Wittichenite	$5Cu_2S\ 2Bi_2S_3$	$Cu_{10}Bi_4S_{11}$	After deducting impurities analyses agree with formula adopted theory Cu 34 9 Bi 45 7 S 19 4%
Boulangerite	$5PbS\ 2Sb_2S_3$	$Pb_5Sb_4S_{11}$	The old formula $3PbS\ Sb_2S_3$, has been discredited and Sjogren s is adopted theory Pb 55 4 Sb 25 7 S 18 9% Dana s Ortho-division
3 1 DIVISION			
PYRARGYRITE GROUP HEXAGONAL TRIGONAL HEMIMORPHIC			
Proustite	$3Ag_2S\ As_2S_3$	Ag_3AsS_3	
Pyrargyrite	$3Ag_2S\ Sb_2S_3$	Ag_3SbS_3	
BOURNONITE GROUP ORTHORHOMBIC			
Seligmannite	$Cu_2S\ 2PbS\ As_2S_3$	$CuPbAsS_3$	
Bournonite	$Cu_2S.2PbS\ Sb_2S_3$	$CuPbSbS_3$	
Aikinite	$Cu_2S\ 2PbS\ Bi_2S_3$	$CuPbBiS_3$	
PYROSTILPNITE GROUP MONOCLINIC			Separated but not named by Dana.
Stylotypite	$3Cu_2S\ Sb_2S_3$	Cu_3SbS_3	Includes falkenhaynite axial angle β near 90° making it peri rhombic
Xanthoconite	$3Ag_2S\ As_2S_3$	Ag_3AsS_3	
Pyrostilpnite	$3Ag_2S\ Sb_2S_3$	Ag_3SbS_3	
Samsonite	$2Ag_2S\ MnS\ Sb_2S_3$	$Ag_4Mn(SbS_3)_2$	
GROUP OF UNKNOWN CRYSTALLIZATION			New Tapalpite (Dana No 143) which would fall in this group is evidently a mixture
Guitermanite	$3PbS\ As_2S_3$	$Pb_3(AsS_3)$	Analyses agree with this simplified formula theory Pb 64 4 As 15 6 S 20 0%

Embrithite	$3PbS \cdot Sb_2S_3$	$Pb_3(SbS_3)_2$	Includes "epiboulangerite" (Dana No. 161); classed by Dana as a variety of boulangerite, although all dependable analyses show that mineral to have a different ratio (see above), some analyses suggest that a 3 : 1 compound may exist, although the homogeneity of the material is very doubtful, theory Pb 58.9, Sb 22.8, S 18.3%
Lillianite	$3PbS \cdot Bi_2S_3$	$Pb_3(BiS_3)_2$	
3.5 : 1 OR 7 : 2 DIVISION			Part of Dana's "Basic division"
TETRAHEDRITE GROUP. ISOMETRIC TETRAHEDRAL			The formula for this group adopted by Dana, $4R_2S \cdot X_2S_3$, does not agree with the analyses, and Tschermak's is here adopted, the more complex formulas of Prior and Spencer and of Kretschmer do not appear to be justified by the evidence
Tennantite	$5Cu_2S \cdot 2(Cu, Fe, Zn)S \cdot 2As_2S_3$	$Cu_{10}(Cu, Fe, Zn)_2As_4S_{13}$	Includes "binnite" (Dana No. 123), theory Cu 51.5, As 20.3, S 28.2%, with up to 7.6% Fe and Zn replacing Cu
Tetrahedrite	$5Cu_2S \cdot 2(Cu, Fe, Zn)S \cdot 2Sb_2S_3$	$Cu_{10}(Cu, Fe, Zn)_2Sb_4S_{13}$	Theory Cu 46.0, Sb 28.9, S 25.1%, with up to 6.8% of Fe and Zn replacing Cu
Schwatzite	$5Cu_2S \cdot 2(Cu, Hg)S \cdot 2Sb_2S_3$	$Cu_{10}(Cu, Hg)_2Sb_4S_{13}$	May contain up to 17% Hg
Freibergite	$5(Cu, Ag)_2S \cdot 2(Cu, Fe)S \cdot 2Sb_2S_3$	$(Cu, Ag)_{10}(Cu, Fe)_2Sb_4S_{13}$	Several other varieties of tetrahedrite have been described, but most if not all appear to be mixtures
LENGENBACHITE GROUP. TRICLINIC			New
Lengenbachite	$Ag_2S \cdot 6PbS \cdot 2As_2S_3$	$Ag_2Pb_6As_4S_{13}$	Hutchinson's formula is adopted

4 : 1 DIVISION			Part of Dana's "Basic division"
ARGYRODITE GROUP	ISOMETRIC TETRAHEDRAL		
Argyrodite	$4Ag_2S \cdot GeS_2$	Ag_8GeS_6	Separated but not named by Dana
Canfieldite	$4Ag_2S \cdot SnS_2$	Ag_8SnS_6	Penfield's formula is adopted. Isomorphous mixtures of this and the preceding occur
JORDANITE GROUP	ORTHORHOMBIC		
Jordanite	$4PbS \cdot As_2S_3$	$Pb_4As_2S_7$	Separated but not named by Dana
Meneghinite	$4PbS \cdot Sb_2S_3$	$Pb_4Sb_2S_7$	
5 : 1 DIVISION			Part of Dana's "Basic division" and of his "Sulpharsenates"
ENARGITE GROUP	ORTHORHOMBIC		
Enargite (part)	$Cu_2S \cdot 4CuS \cdot As_2S_5$	Cu_3AsS_4	Often classed as a sulfarsenate, but its occurrence and associations suggest that its high sulfur content is due to the presence of cupric copper; analyses show wide variation, approaching luzonite (below)
Famatinite	$Cu_2S \cdot 4CuS \cdot Sb_2S_5$	Cu_3SbS_4	Compare note on enargite; includes goldfieldite, a variety containing admixed tellurium, etc.
STEPHANITE GROUP	ORTHORHOMBIC HEMIMORPHIC		Separated but not named by Dana
Stephanite	$5Ag_2S \cdot Sb_2S_3$	Ag_5SbS_4	
Geocronite	$5PbS \cdot Sb_2S_3$	$Pb\ SbS_4$	Includes kilbrickenite (Dana No. 154), the analyses and properties of the two being essentially identical
GROUP OF UNKNOWN CRYSTALLIZATION			New
Sulvanite	$Cu_2S \cdot 4CuS \cdot V_2S_5$	Cu_3VS_4	Probably analogous to enargite
6 : 1 DIVISION			Part of Dana's "Basic division" and part of his "Sulpharsenates"
BEEGERITE GROUP	ISOMETRIC		Separated but not named by Dana
Beegerite	$6PbS \cdot Bi_2S_3$	$Pb_6Bi_2S_9$	Homogeneity uncertain, yet shows distinctive mineragraphic characters (D. & F.)

GROUP OF UNKNOWN CRYSTALLIZATION			
			New Richmondite if homogeneous would belong here
Luzonite (part)	$6CuS \cdot As_2S_3$	$Cu_6As_2S_9$	Some massive luzonite has been shown by mineragraphic study to be distinct from normal enargite although other so-called luzonite is crystallographically identical therewith; theory Cu 46.5, As 18.3, S 35.2%
(High sulfur famatinite)	$6CuS \cdot Sb_2S_3$	$Cu_6Sb_2S_9$	Corresponds to preceding; theory Cu 41.9, Sb 26.4, S 35.2%
8 : 1 DIVISION			Part of Dana's Basic division
POLYBASITE GROUP: MONOCLINIC			Separated but not named by Dana
Pearceite	$8Ag_2S \cdot As_2S_3$	$Ag_{16}As_2S_{11}$	Van Horn and Cook's formula is adopted
Polybasite	$8Ag_2S \cdot Sb_2S_3$	$Ag_{16}Sb_2S_{11}$	Formula assumed to correspond to the preceding; agrees well with analyses; theory Ag 74.4, Sb 10.4, S 15.2%
9 : 1 DIVISION			Part of Dana's Sulpharsenates
EPIGENITE GROUP: ORTHORHOMBIC			Separated but not named by Dana
Epigenite	$3Cu_2S \cdot 9CuS \cdot 6FeS \cdot 2As_2S_3$	$Cu_{15}Fe_6(AsS_4)_4$	Rammelsberg's formula is adopted
12 : 1 DIVISION			Part of Dana's Basic division
POLYARGYRITE GROUP: ISOMETRIC			Separated but not named by Dana
Polyargyrite	$12Ag_2S \cdot Sb_2S_3$	$Ag_{24}Sb_2S_{15}$	

ANALYTICAL CHEMISTRY.—*Note on crucibles used in rock analysis.*[1] HENRY S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington

It may be of interest to those who are engaged in the analysis of silicates or silicate rocks to put on record my experience with a palau and an iridium-platinum crucible, which have been used for the fusion of rock powders with sodium carbonate. Palau is an alloy, introduced a few years ago as a substitute for platinum, and is composed of 80 per cent gold and 20 per cent palladium A small percentage of iridium is often alloyed with platinum to impart greater stiffness, as pure platinum is noticeably soft.[2]

It is well known to those analyzing rocks that, when platinum or iridium-platinum crucibles are used for the sodium carbonate fusion, the cold cake sometimes adheres obstinately to the crucible walls, after slight soaking with water in the crucible and gentle heating over a low flame, instead of freeing itself as it "should do" This behavior necessitates prolonged digestion of the adherent melt so as to dissolve the cake, which sometimes results in loss of substance, and always in loss of time

This unfortunate behavior is caused, in many cases, by indentations or other irregularities in the crucible wall or bottom, brought about by careless handling, such as squeezing the crucible to loosen the cake It is also apparently rendered more liable to happen through the ogee-like curve assumed by the lower parts of the sides of platinum crucibles after long usage, and is easily brought about by attempting to remove the cake before it is quite cold and before it has separated or has started to separate from the walls The roughness of the inner surface of platinum crucibles is also a determining factor Even if the

[1] Received November 15, 1920

[2] For some studies on the quality and properties of various platinum wares on heating see R W HALL, Journ Amer Chem Soc **22**: 494 1900, HULETT and BERGER, Journ Amer Chem Soc **26**: 1512 1904, HILLEBRAND, WALKER, and ALLEN, Journ Ind Eng Chem **3**: 686 1911, BURGESS and SALE, Journ Ind Eng Chem **6**: 452 1914, **7**: 561 1916, Bull Bur Standards **12**: 289 1915 (Sci Paper **254**), BURGESS and WALTENBERG, Bull Bur Standards **13**: 365 1916 (Sci Paper **280**), HILLEBRAND, U S Geol Survey Bull **700**: 102 (Note 3). 1919

cake as a whole separates from the walls, there is often left a narrow patch or series of patches around the upper edge of the cake, strongly adherent to the crucible wall, though this is of less consequence. I have frequently had the opportunity to observe this annoying occurrence, with both platinum and iridium-platinum crucibles, and have elsewhere called attention to it.[3]

In the course of making many rock analyses it was found that crucibles made of pure platinum (Heraeus) were very soft, and apparently not sufficiently polishable internally, so that a ready loosening of the cake from them was seldom accomplished; although for general ignition purposes they are admirable, because of the negligible loss of weight on ignition. Crucibles made of platinum alloyed with a small amount of iridium (such as were used in my laboratory from 1896 to 1912), were found to be much better for the carbonate fusion. They are stiffer than pure platinum, and are therefore less liable to indentation, and are also susceptible of a higher polish. The cake loosened more often and more readily than from pure platinum, but still adhered occasionally. In the spring of 1918 I began using a palau crucible, chiefly with the object of testing the material in actual rock analysis, because of the constantly augmenting cost of platinum. To my great gratification it was found that the cold sodium carbonate cake always separated easily, quickly, and almost or quite completely from the crucible, far better and more surely than it had done from either platinum or iridium-platinum crucibles of about the same size and shape With this crucible, which is now reserved for this purpose, I have made many fusions with sodium carbonate, but have not once found the cake to adhere—in each case it has freed itself rapidly and completely, on gentle heating with enough water to cover it.

This satisfactory behavior is the more noteworthy because this crucible is slightly indented, at about the level of the upper edge of the melt, around the zone of contact with the supporting triangle.[4] Apparently the palau softens rather more than plati-

[3] H S. Washington. *Manual of the chemical analysis of rocks* (New York, 1919), pp 132 and 135

[4] A triangle of fused silica or of pipe stems must be used with palau crucibles Platinum triangles alloy with palau and ruin both crucible and triangle.

num or iridium-platinum on strong ignition. It is to be noted, by the way, that for my fusions the blast was never used. The heating was done for the most part over a half-high Bunsen burner flame, which is quite sufficient to fuse the carbonate mixture, and was usually supplemented by a Meker burner during the last fifteen minutes or so. The time of heating varied from forty-five minutes to one hour. About 1 gram of rock powder and 5 grams of sodium carbonate were used for each fusion.

The cause of this freedom from adhesion of the cake to the palau crucible walls is uncertain. I am inclined to attribute it chiefly, if not wholly, to the superior hardness and stiffness of the alloy, and especially to its superior polish. The iridium-platinum alloy is almost, but not quite, equal to palau in these respects, while pure platinum is much softer and susceptible of less polish. Whatever the cause may be, and whether the same behavior is true of palau crucibles in general, the observations mentioned indicate that palau is superior to iridium-platinum, and still more to pure platinum, for the purpose of the sodium carbonate fusion in rock analysis.

I have not tested the resistance of the palau crucible to fusion with potassium (or sodium) pyrosulfate, though some of the references given above indicate that it loses more weight during the operation than platinum or iridium-platinum.

It may, however, be of interest to give the data as to loss in weight of the palau crucible, as well as of an iridium-platinum crucible, during some rather long series of fusions of rock powder with sodium carbonate. It must be premised that both crucibles were reserved for this operation, though occasionally they were used for the evaporation of the solution of alkali chlorides in the determination of potash and soda; this, however, would not noticeably affect their weights.

Since June 12, 1918 (when it was used for the first time), the palau crucible has been used 47 times for a sodium carbonate fusion. Since that date the crucible has not been scrubbed with sand, nor was it used for the pyrosulfate fusion or other ignition that might presumably affect its weight. The evaporations for alkali chlorides for which it was used were made at 100°, and

were followed by a very gentle heating after dryness to drive off the ammonium chloride. It would thus appear that the sodium carbonate fusion was the only factor that might lead to loss in weight, whether through the temperature of ignition or through the action of the carbonate. The same balance and the same weights were used throughout the series.

On June 12, 1918, the weight of the palau crucible was 32.0712 g., and the weight diminished steadily and with great regularity through the series of 47 carbonate fusions until the last weighing, on November 8, 1920, when it was 32.0613 g. The difference is 0.0099 g, giving an average loss in weight for each fusion of 0.00021 g, that is, about 0.2 mg.

For comparison with this there was taken a series of 21 weighings of an iridium-platinum crucible (percentage of iridium unknown) The first weighing of the series was made just after the crucible had been scrubbed with sea sand (Dec 5, 1914), and the last when another set of weights was put into use (Sept. 9, 1916) This crucible, likewise, was reserved for the sodium carbonate fusions, and only occasionally for the evaporation of the alkali chlorides. The initial weight of this crucible was 30 1493 g, and the final, after a series of steadily diminishing weights, was 30 0656 g This gives a total loss in weight of 0 0099 g (by coincidence identical with the other), and an average loss in weight of 0.00047 g Thus the iridium-platinum crucible showed an average loss, due to the fusions, rather more than twice that of the palau. It is well known that crucibles made of platinum containing iridium lose weight very noticeably on ignition, which is commonly ascribed to volatization of iridium, and this factor would seem to have had influence here.

No estimate was made of the average loss in weight suffered by pure platinum crucibles which had been in use before the iridium-platinum one, as my notes showed that they had been used occasionally for the fusion with potassium pyrosulfate, which would cause a serious and rather irregular loss (which may be as much as 5 mg.). For the same reason a long series of data on my crucibles that had been used in my own laboratory at Locust, New Jersey, from 1896 to 1912 was rejected.

Conclusions.—The cold cake from the sodium carbonate fusion is freed very readily and completely from a palau crucible, much more readily than from one of iridium-platinum, and still more so than from one of pure platinum. The average loss in weight after each sodium carbonate fusion for the palau crucible investigated was about 0.2 mg , and that of an iridium-platinum crucible was about 0.5 mg. The greater average loss of the latter may be ascribed, in part, to volatilization of iridium.

GENETICS.—*Linkage between brachytic culms and pericarp and cob color in maize.*[1] J H KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture (Communicated by G. N Collins)

Characters which tend to be inherited together are said to be linked, on the assumption that the genes for such characters are arranged in a linear series on the same chromosome. The agreement between the number of groups of linked characters and the number of chromosomes and the linear arrangement of the genes has been demonstrated genetically with remarkable detail for the fruit fly (*Drosophila melanogaster*) by Morgan and his co-workers and for other species of *Drosophila* by Metz

While it seems almost certain that groups of linked characters corresponding to the number of chromosomes will be found also in plants, nevertheless, up to the present time this has not been demonstrated

In several respects plants would seem to offer better opportunities than animals for studies of this kind, and among plants *Zea mays* has many advantages. In the number and frequency of variations alone *Zea* probably exceeds *Drosophila*, while in the physiological importance of the structures involved it far surpasses any animal organism where much less fundamental changes are almost certain to be fatal. The number of chromosomes, however, is relatively large, necessitating the intensive study of many characters, but with each succeeding linkage or demonstrated independence progress becomes more rapid.

[1] Received November 11, 1920.

Since the first pair of linked characters was found in maize in 1911, six others have been reported, the present pair making the eighth.

The linked characters reported thus far are listed below:

Characters	Factor symbols	Per cent crossovers	Reported by
Waxy endosperm	Xx		Bregger, 1918
Aleurone color	Cc	25	Collins and Kempton, 1911
Endosperm color	[b]	25	Kempton, 1917
Albino seedlings	[b]		
Golden leaf color	Gg		
Aleurone color	Rr	23	Lindstrom, 1918
Golden leaf color	Gg		
Yellow seedling	Ll	19	Lindstrom, 1918
Yellow seedling	Ll		
Aleurone color	Rr	0	Lindstrom, 1918
Sweet endosperm	Ss		
Podded seeds	Tt	18 5	Jones, 1919
Spotted aleurone	Ss		
Aleurone color	Rr	12 5	Kempton, 1919[a]
Brachytic culms	Br br		
Pericarp and cob color	[b]	35+	Reported here

[a] Emerson (1918) explains this relationship in another way

[b] Actual factors involved not identified

Brachytic culms, a variation in which the internodes are very much shortened, made its appearance in a second generation hybrid and thus far behaves as a unit character in crosses with the normal form. (Kempton 1920) Unlike Emerson's extreme dwarf anther ear (Emerson 1912) the brachytic variation is not readily recognized in the seedling stage but is conspicuous before the tassel appears.

This variation has been crossed with several others in an effort to determine its relationships Many of these crosses have been carried through the second generation and most of them indicate little if any association of the brachytic character with the other variations In some of the crosses the results were conflicting and further analysis is necessary. One relationship, however, seems certain, since it is corroborated in three unrelated crosses. This is the association of brachytic culms with cob and pericarp color.

Through the courtesy of Prof. R. A. Emerson we were supplied with a sample of his liguleless leaf variation (Emerson 1912). This variation is one in which the line of demarcation between the sheath and the blade is lost and the leaves possess neither ligules nor auricles. In the strain supplied us the color of the pericarp and cob was red. This liguleless leaf variation was crossed with a strain of brachytic culms which had a white pericarp and cob.

The plants of the first generation were all normal in stature with red cobs, and pericarps and the leaves all had the normal ligules. Nine of these first generation plants were self-pollinated and separate progenies were grown from each of the resulting ears

With respect to the pericarp and cob colors only two classes of plants were obtained in the second generation, namely, those with a red cob and pericarp and those with a white cob and pericarp. This is in accord with the results of Emerson, 1911.

The other two characters involved (brachytic culms and liguleless leaves) occurred in all possible combinations with each other and with the cob and pericarp colors. Since the color of the cob and that of the pericarp were always alike on any given plant, it has been found convenient to refer to this character simply as the color of the cob.

The distribution of the plants of the nine progenies for color of the cob and character of the culm is shown in table 1.

In each case the red cob color is found to be associated with normal stature which is the parental combination. Although the degree of association varies, the coefficient of association of 0 463 ± 0.038 for the entire group indicates a crossing-over percentage of 35.5.

Practically the same percentage of "crossovers" was obtained from a cross between a Maryland red dent variety of normal stature with the white-cobbed strain of the brachytic variation. The first generation plants of this cross, as in the liguleless-brachytic cross, were all normal in stature with red cobs and pericarps

TABLE 1

DISTRIBUTION OF PLANTS WITH RESPECT TO COB COLOR AND THE CHARACTER OF THE CULM IN THE SECOND GENERATION OF A HYBRID BETWEEN LIGULELESS LEAVES AND BRACHYTIC CULMS (PARENTAL COMBINATION RED COB NORMAL STATURE)

Progeny	Red cob Normal stature	Red cob Brachytic stature	White cob Normal stature	White cob Brachytic	Total	Per cent White cob	Per cent Brachytic	Q	Per cent Crossover
L1	215	46	60	36	357	26.8 ± 1.6	23.0 ± 1.5	0.474 ± 0.072	35.5
L2	90	22	21	13	146	23.3 ± 2.4	24.0 ± 2.4	0.434 ± 0.119	38.7
L3	128	26	43	18	215	28.4 ± 2.1	20.5 ± 1.9	0.12 ± 0.118	46.4
L4	53	4	17	7	81	29.6 ± 3.4	13.6 ± 2.6	0.69 ± 0.103	27.9
L5	85	14	27	21	147	32.6 ± 2.5	23.8 ± 2.4	0.65 ± 0.085	29.4
L6	83	13	21	9	126	23.8 ± 2.6	17.5 ± 2.0	0.464 ± 0.123	35.9
L7	47	7	15	9	78	30.7 ± 3.5	20.5 ± 3.0	0.605 ± 0.123	31.3
L8	54	8	25	7	94	34.0 ± 3.3	15.9 ± 2.4	0.308 ± 0.162	40.6
L9	69	15	22	9	115	27.0 ± 2.8	20.9 ± 2.3	0.305 ± 0.138	40.7
Total	824	155	251	129	1357	28.0 ± 0.08	20.9 ± 0.07	0.463 ± 0.038	35.5

In the second generation it was found that the pericarps and cob colors again behaved as a unit, only plants with red cobs and red pericarps and plants with white cobs and white pericarps being found.

The distribution of the plants with respect to the color of the cob and the character of the culm is shown in table 2

Although, as in the first instance, the progenies vary in the degree of relationship, the per cent of "crossovers" for the entire group is remarkably close to that of the liguleless × brachytic hybrid

A third cross involving brachytic culms and cob color has also been carried through the second generation In this cross the parent of normal stature was a segregate from a cross between *Zea tunicata* and *Z ramosa* and had a red cob but a white pericarp, while the brachytic parent, as in the other crosses, had both cob and pericarp white

TABLE 2

Distribution of Plants with Respect to Cob Color and the Character of the Culm in the Second Generation of a Hybrid between a Maryland Dent Variety of Normal Stature and Red Cob and the Brachytic Variation with White Cob

Progeny	Red cob Normal stature	White cob Normal stature	Red cob Brachytic	White cob Brachytic	Total	Per cent White cob	Per cent Brachytic	Q	Per cent Crossover
Ah487L 1	206	68	59	32	365	24 9 ± 1 5	27 4 ± 1 6	0 243 ± 0 087	42 6
L 2	60	17	15	7	99	24 3 ± 2 9	22 2 ± 2 8	0 246 ± 0 165	42 4
L 3	46	9	5	9	69	26 1 ± 3 6	20 3 ± 3 3	0 805 ± 0 076	23.1
L 4	28	16	6	11	61	44 3 ± 4 3	27 8 ± 3 9	0 525 ± 0 10	34 0
L 5	31	13	9	10	63	36 5 ± 4 1	30 1 ± 4 0	0 453 ± 0.17	36 3
L 6	41	14	9	9	73	31 5 ± 3 7	24 6 ± 3 5	0 491 ± 0 15	35 0
L 7	36	8	5	4	53	22 6 ± 3 9	17 0 ± 3 5	0 566 ± 0 21	32 7
L 8	42	19	10	9	80	35 0 ± 3 6	23 7 ± 3 2	0 331 ± 0 17	39 9
L 9	71	14	9	14	108	25 9 ± 2 9	21 3 ± 2 6	0 765 ± 0 07	25 0
L10	55	13	9	8	85	24 7 ± 3 2	20 0 ± 2 9	0 580 ± 0 13	32 1
L11	70	19	9	6	104	24 0 ± 2 9	14 4 ± 2 4	0 422 ± 0 14	37 1
Total	686	210	145	119	1160	28 4 ± 0 09	21 9 ± 0 08	0 456 ± 0 041	36 1

TABLE 3

Distribution of Plants with Respect to Cob Color and the Characters of the Culm in the Second Generation of a Hybrid between a Tunicata × Ramosa Segregate with Red Cobs and Normal Stature and the Brachytic Variation with White Cob (Parental Combination Red Cob Normal Stature)

Progeny	Red cob Normal stature	White cob Normal stature	Red cob Brachytic stature	White cob Brachytic	Total	Per cent Brachytic	Per cent White cob	Q	Crossover
L1	208	63	42	36	349	22 4 ± 1 6	28 4 ± 1 6	0 478 ± 0 072	35 5
L16	72	31	17	8	128	19 5 ± 2 3	31 2 ± 2 8	0 044 ± 1 53	48 8
L17	67	19	25	20	131	34 3 ± 2 8	29 8 ± 2 7	0 476 ± 1 20	35 1
L19	48	4	24	9	85	38 8 ± 3 6	15 3 ± 2 6	0 637 ± 1 15	29 6
Total	395	117	108	73	693	26.1 ± 1 1	27 4 ± 1 1	0 39 ± 0 056	38 1

TABLE 4

DISTRIBUTION OF PLANTS WITH RESPECT TO THE CHARACTER OF THE LEAVES AND CULMS IN THE SECOND GENERATION OF A HYBRID BETWEEN LIGULELESS LEAF AND BRACHYTIC CULM (PARENTAL COMBINATION LIGULELESS NORMAL STATURE)

Progeny	Ligule Normal stature	Ligule Brachytic stature	Liguleless Normal stature	Liguleless Brachytic stature	Total	Per cent Liguleless	Per cent Brachytic	Q	Per cent Crossover
Ah489L1	216	71	61	20	368	22.0 ± 1.5	24.7 ± 1.5	0.305 ± 0.097	40.5
L2	90	33	33	5	161	23.6 ± 2.3	23.6 ± 2.3	0.413 ± 0.142	37.1
L3	128	44	48	13	233	26.1 ± 1.9	24.5 ± 1.9	0.119 ± 0.122	46.3
L4	64	12	24	7	107	30.9 ± 3.0	17.3 ± 2.5	—0.217* ± 0.161	56.6
L5	84	31	32	4	151	23.8 ± 2.3	23.2 ± 2.3	0.494 ± 0.138	34.5
L6	83	24	36	1	144	17.4 ± 2.2	25.7 ± 2.5	0.825 ± 0.094	20.7
L7	63	20	30	5	118	21.2 ± 2.6	29.7 ± 2.8	0.311 ± 0.172	40.3
L8	71	20	25	7	123	22.0 ± 2.6	26.0 ± 2.7	0.003 ± 0.161	50.0
L9	82	31	23	5	141	25.5 ± 2.5	19.8 ± 2.3	0.27 ± 0.160	41.6
Total	881	286	312	67	1549	24.5 ± 0.07	22.8 ± 0.08	0.204 ± 0.049	43.7

* The minus sign indicates that the coefficient of association is between the character combinations as they did not occur in the parents

TABLE 5

DISTRIBUTION OF SAME PLANTS AS IN TABLE 4 WITH RESPECT TO THE COLOR OF THE COB AND THE CHARACTER OF THE LEAF (PARENTAL COMBINATIONS RED COB LIGULELESS AND WHITE COB LIGULE)

Progeny	Red cob Ligule	Red cob Liguleless	White cob Ligule	White cob Liguleless	Total Plants	Per cent White cob	Per cent Liguleless	Q	Per cent Crossovers
L1	205	56	73	22	356	26.7 ± 1.6	21.9 ± 1.5	—0.049* ± 0.092	51.3
L2	85	27	28	6	146	23.3 ± 2.4	22.6 ± 2.3	0.194 ± 0.157	43.9
L3	112	42	49	12	215	28.4 ± 2.1	25.1 ± 2.0	0.209 ± 0.130	43.2
L4	42	15	18	6	81	29.6 ± 3.4	26.0 ± 3.3	0.034 ± 0.212	48.9
L5	68	31	42	6	147	30.6 ± 2.5	25.1 ± 2.4	0.457 ± 0.145	35.8
L6	68	28	27	3	126	23.8 ± 2.5	24.6 ± 2.6	0.599 ± 0.138	30.8
L7	43	11	20	4	78	30.7 ± 3.5	19.2 ± 3.0	0.123 ± 0.212	46.1
L8	47	15	27	5	94	34.1 ± 3.2	21.3 ± 2.8	0.688 ± 0.146	27.3
L9	73	11	23	8	115	27.0 ± 2.6	16.5 ± 2.2	—0.393* ± 0.138	62.3
Total	743	236	307	72	1358	27.9 ± 0.8	22.7 ± 0.8	—0.151 ± 0.055	45.3

* The minus sign indicates that the coefficient of association is between the character combinations as they did not occur in the parents.

In the first generation the plants showed a segregation with respect to cob color, half the plants having red, the other half white cobs, indicating that the red-cobbed parent was heterozygous for cob color. Four self-pollinated ears with red cobs were obtained and progenies of these had approximately three plants with red cobs to one with white. These four progenies are fairly uniform with respect to the Mendelian ratios. The distribution of the plants with respect to cob color and culm characteristics is shown in table 3 The percentage of "crossovers" varies from 29.6 to 48 8 with an average for the group of 38.1. This percentage, though somewhat larger than in the other two hybrids, does not vary from them by an amount too large to be ascribed to chance.

It may be concluded, therefore, that the genes for cob color and stature are located in the same chromosome and rather widely separated, the distance being between 31 and 43 units.

The nine second-generation progenies of the liguleless × brachytic cross afford also an opportunity to measure the interrelations of the leaf and culm characters These nine progenies vary in the degree of relationship between the brachytic stature and the liguleless leaf. In all but one progeny the correlations were between normal stature and liguleless leaf which is the parental combination The classes of plants are shown in table 4. In the one exception the probable error does not preclude placing it with the others since the deviation from the mean of the group is but 2 5 times the error.

The correlation of 0 204 ± 0.049 for the entire group indicates a rather loose linkage, the percentage of crossovers being 43.7. The deviation from independence or 50 per cent crossing over is slightly over 4 times the error It would seem, therefore, that if the genes for these characters are located on the same chromosome they are widely separated.

If it is held that the genes for the brachytic and liguleless characters are located in the same chromosome 44 units apart it then follows from the relation of brachytic culms to cob color that the gene for liguleless leaves must be either 8 or 80 units from that for cob color. The classes of plants are shown in

table 5. It will be seen from this table that the relation of cob color to liguleless leaf is very erratic with a mean crossover percentage of 45 3, which is practically independence. It is possible, therefore, that the slight relationship of the leaf and culm characters indicated in table 4 is but the result of chance and that the genes for these two characters are borne in reality by separate chromosomes, though this point cannot be determined definitely until some character is found that is independent of cob color and measurably correlated with brachytic culms.

Literature cited

Brегger, T. *Linkage in maize The C aleurone factor and waxy endosperm* Amer Nat 52: 57–61 1918

Collins, G N, and Kempton, J H *Inheritance of waxy endosperm in hybrids of Chinese maize IV Conférence Internationale de Génétique*, Paris, 1911

Emerson, R A *Genetic correlation and spurious allelomorphism in maize* 24th Ann Rep Nebraska Agric Exp Station, 1911

The inheritance of certain abnormalities in maize Amer Breeders Assoc, 1912

A fifth pair of factors, A a, for aleurone color in maize, and its relation to Cc and Rr pairs Cornell Univ Agric Exp Sta Memoir 16. November, 1918

Kempton, J H *A correlation between endosperm color and albinism in maize* This Journal 7: 146–149 March 19, 1917

Inheritance of spotted aleurone color in hybrids of Chinese maize Genetics 4: 261–274 May, 1919

Jones, D F, and Gallastegui, C A *Some factor relations in maize with reference to linkage* Amer Nat. 53 May, June, 1919

Lindstrom, E W *Chlorophyll inheritance in maize* Cornell Univ Agric. Exp. Sta. Memoir 13. Aug., 1918

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY OF WASHINGTON

833RD MEETING

The 833rd meeting was held at the Cosmos Club, March 27, 1920. President SOSMAN presided and about 75 persons were present. The speaker of the evening was Dr. SAUL DUSHMAN, of the General Electric Co., who presented a paper on *Methods for the production and measurement of extremely low pressures.*

The pressures dealt with under this heading range from one millionth of an atmosphere (1 bar) to pressures lower than 10^{-4} bar. For the proper operation of a number of hot cathode devices, it is absolutely necessary to obtain pressures which are well below 10^{-2} bar The methods used for the production of high vacua may be classified for convenience under three headings (1) *Mechanical pumps*, of which the rotary mercury or oil pump and Gaede molecular pump are typical illustrations With the former, pressures as low as 10^{-1} bar can be attained, while the Gaede molecular pump is capable of producing vacua as high as 10^{-4} bar. (2) *Mercury vapor pumps* The Gaede diffusion pump and Langmuir condensation pumps are both capable of producing extremely high vacua. The latter is, however, much more rapid in its operation (3) *Physico-chemical methods* By means of charcoal immersed in liquid air it is possible to obtain extremely low pressures in devices in which gas is being evolved continually either from metal parts or glass walls The volatilization of calcium has been suggested by Soddy as another method for producing low pressures in sealed-off tubes

In the actual exhaust operations, it is of importance to consider the resistance to flow of glass tubes, as well as the speed of the pump. The laws of flow of gases at low pressures have been studied by Smoluchowski and Knudsen and it is possible by means of the formulae derived by the latter to calculate the effect of glass tubing of given dimensions on the speed of exhaustion.

Methods of measuring low pressures.—The McLeod gauge is the simplest but is not always applicable and is not very sensitive for pressures below 10^{-1} bar. Pirani and Hale have developed an electrical resistance method which is capable of measuring pressures as low as 10^{-2} bar. The molecular gauge devised by Langmuir is sensitive to 10^{-4} bar, but is difficult to construct. Knudsen developed a radiometric type of gauge and various modifications of it have been designed by which pressures as low as 10^{-5} bar can be measured The simplest method of measuring low pressures is the ionization gauge. This is very convenient for measuring the pressure in sealed-off hot cathode devices and incandescent lamps.

The paper was illustrated by lantern slides, and was discussed by Messrs. BURKA, FOOTE, SOSMAN, MCKEEHAN, WHITE, STIMSON, MERWIN, KANOLT, and WENNER.

Informal presentations: At the request of Mr. C. A. BRIGGS, Mr. W. J. HUMPHREYS spoke briefly concerning the aurora of March 22, 1920.

Mr. G. F. HULL described an unusual aurora which he had witnessed.

834TH MEETING

The 834th meeting was held at the Cosmos Club April 10, 1920, with 50 persons present, and Vice-President CRITTENDEN in the chair. The program was as follows:

H. C. DICKINSON: *Physical laboratory methods applied to aircraft engines at high altitudes.*

A special laboratory equipped for making precise determinations of the various factors in the performance of aircraft engines under all conditions of operation was developed at the Bureau of Standards during the war. The methods of measuring power, heat and temperature distribution, pressure, densities, etc., are distinctly those of the physical laboratory. In addition to studies of engine performance, parallel investigations have been made of the problems of ignition, carburetion, cooling, lubrication, etc., for which special laboratory equipment has been provided.

In connection with these researches, a number of special instruments have been designed. These include a balanced-diaphragm pressure indicator for recording engine cylinder pressures accurately by a point to point method, an instrument for measuring the clearance volume in engine cylinders, and a device for measuring conveniently the maximum cylinder pressure.

The paper was illustrated by lantern slides, and was discussed by Mr. BUCKINGHAM.

M. D HERSEY: *Old and new problems of aeronautic instruments.*

The speaker called attention to charts and instruments which had accumulated on this subject since the occasion of his last paper before the Society, which was the year before the war.

The charts were as follows:

1 Rejection limits for aviation altimeters.
2 Temperature lag of aneroids.
3 The two temperature effects on instruments with elastic action
4 Theory of ground speed indicator
5. Results of Venturi tube experiments in air and water
6. Results of Venturi tube experiments in vacuum wind tunnel and on an airplane.
7. Dimensional theory of compass damping
8 List of new problems awaiting solution as follows
   (*a*) Stabilizer for ground speed indicators
   (*b*) Air speed indicator for dirigibles
   (*c*) True altitude meter
   (*d*) Gyroscopic or double pivot compass.
   (*e*) Temperature compensated diaphragms with small elastic lag

The instruments shown were as follows:

1. Vibration stand for instruments, together with Dr. Dickinson's vibrometer
2. Precision altimeter.
3. Group showing evolution of rate-of-climb indicators.
4. Group of various Pitot and Venturi tubes.
5. Working model of Franklin stabilizer.
6. Air damped compass for dirigibles.
7. Working model of ground speed indicator
8. Combination inclinometer, banking indicator and gyroscopic turn indicator in operation.

Lantern slides were also shown as follows:

1. Certificates showing test results on aneroid barometers tested at the government laboratories of England, France, Germany and the United States
2. A group of curves showing errors of aneroids.
3. Diaphragm investigation exhibit
4. Dummy observer utilizing moving picture film for instrument observations in flight (3 views)

The paper was discussed by Messrs. CROOK and TUCKERMAN

S. J. MAUCHLY, *Recording Secretary.*

ARCHAEOLOGICAL SOCIETY

The 19th annual meeting of the Washington Society of the Archaeological Institute of America was held at the home of Mr. ROBERT LANSING on Saturday, November 13, 1920.

Sir WILLIAM RAMSAY gave an illustrated lecture on *An archaeological retrospect and prospect in Anatolia.*

The following officers were elected for the year 1921· *President*, ROBERT LANSING, *Vice-Presidents*, ROBERT M. THOMPSON, Miss MABEL BOARDMAN, HENRY WHITE and Mrs. H. F. DIMOCK; *Secretary*, MITCHELL CARROLL; *Associate Secretary*, Miss HELEN WRIGHT, *Treasurer*, JOHN B. LARNER; *Councillors*, ROBERT LANSING (ex-officio), CHARLES HENRY BUTLER, MITCHELL CARROLL (ex-officio), WILLIAM MILLER COLLIER, F. WARD DENYS, WILLIAM P. ENO, WILLIAM H. HOLMES (ex-officio), JOHN B. LARNER, H. B F. MACFARLAND, JAMES PARMELEE, J. TOWNSEND RUSSELL and ROBERT M. THOMPSON; *Executive committee*, the above named officers and ALBERT DOUGLAS, Miss AMARYLLIS GILLETT, GILBERT GROSVENOR, MARTIN A. KNAPP, CHARLES COLFAX LONG and GEORGE OAKLEY TOTTEN, JR.

MITCHELL CARROLL, *Secretary*

SCIENTIFIC NOTES AND NEWS.

A luncheon was given in the Smithsonian Building on November 16, in honor of the seventieth birthday of Dr. J. WALTER FEWKES, chief of the Bureau of American Ethnology.

Dr. J. PAUL GOODE, professor of geography at the University of Chicago, gave an address before the General Staff at the Army War College on November 12, on *The geographic and economic foundations of the world war.*

Mr. RALPH W HOWELL, geologist with the U. S. Geological Survey, was killed by native raiders in Beluchistan in the latter part of November, 1920 He was engaged at the time in oil exploratory work for Pearson & Son of London, and was working near the Beluchistan-Punjab border in an area that had been considered safe from bandits. Mr. Howell was born in 1886, and had been a member of the Survey staff since 1913. He was granted leave of absence from the Survey in October 1919 to engage in private work. He was a member of the Geological Society.

A series of lectures on *Heaviside's operational methods as applied to physical problems* is being given at the Bureau of Standards by Professor A. PRESS.

Rear Admiral EDWARD R. STITT, of the Naval Medical Corps, has been appointed surgeon general of the Navy and chief of the bureau of medicine and surgery, Navy Department, succeeding Rear Admiral W. C. BRAISTED, who has been surgeon general of the Navy since 1914, and who went on the retired list in November.

Dr T WAYLAND VAUGHAN, geologist in charge of the Coastal Plain section of the U S. Geological Survey, is on leave for several months to engage in private work in Mexico.

Prof BAILEY WILLIS, formerly geologist on the U. S. Geological Survey, and now professor of geology at Leland Stanford Junior University, California, is spending several months in Washington.

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MINERALOGY.—*Bementite and neotocite from western Washington, with conclusions as to the identity of bementite and caryopilite.*[1] J. T. PARDEE, E. S. LARSEN, JR., and GEORGE STEIGER, U. S. Geological Survey.

Occurrence and association

Specimens representative of manganese-bearing deposits in western Washington collected in 1917 and 1918 by J. T. Pardee and examined microscopically and chemically by Messrs Larsen and Steiger, respectively, are determined to be chiefly bementite, a hydrated silicate of manganese. The material was collected at the Black and White, Apex, Triple Trip and other mines and prospects along the north and south forks of Skokomish River, Mason County, Washington, and from A. V. Ginnett's prospect on Fidalgo Island south of Anacortes. Similar material was found by Prof. Henry Landes at the Tubal Cain mine west of Quilcene and is reported by others to occur on the mainland about 10 miles northeast of Anacortes and at a locality a few miles south of Lake Queniault. Most of these occurrences are within a narrow belt about 70 miles long that extends from the vicinity of Lake Queniault northeastward into the drainage area of Dungeness River and covers part of the eastern slope of the Olympic Mountains. The remainder, comprising the deposits near Anacortes, are about 60 miles further northeastward. This rather extensive occurrence of bementite in Washington is interesting in view of the fact that so far as known that mineral is rare elsewhere. Dana[2] mentions only one locality of its occurrence in America, namely, Franklin Furnace, New Jersey.

[1] Published by permission of the Director of the U. S. Geological Survey. Received November 26, 1920.

[2] *A system of mineralogy*, ed. 6, p. 704, 1914, third appendix to same, p. 12, 1915.

The belt in which bementite is found is part of a densely forested and extremely rugged area in which the local relief ranges from 2,000 to 6,000 feet or more. It has not been thoroughly prospected or even explored in detail, though most of it is within 15 or 20 miles of Puget Sound From Hoodsport the deposits along the north and south forks of Skokomish River can be reached over a fairly good road and trails, but most other places in the belt are rather difficult of access.

The rocks of the bementite area are chiefly greenstone, arkosic sandstone, argillite, and a deep red or maroon impure limestone that forms discontinuous layers and lenses These rocks are steeply tilted and compressed and show the effects of regional metamorphism. The strike appears to be generally northeastward parallel with the distribution of the deposits The limestone contains poorly preserved fossils of minute foraminifera determined by Dr T. W Stanton as most probably belonging to the genus *Globigerina*, which may indicate the rock to be Mesozoic or younger The field relations show only that the rock group is older than the recognized Tertiary of the region

The deposits that contain the bementite are either inclosed by or closely associated with the limestone. They are tabular or lens-like bodies, commonly from 5 to 20 or 30 feet in thickness and to be measured in their other dimensions by hundreds or thousands of feet. Parts of them are a bright red jaspery-looking rock composed of fine-grained quartz and hematite mixed in various proportions Locally this material grades into practically unmixed hematite The remaining and commonly the larger parts of the bodies are chiefly a dense very finely crystalline rock that consists chiefly of bementite No dense specimen was found in which the bementite was entirely unmixed with other minerals, and the texture of the rock is so fine that a heavy-solution separation, as described further on, was found necessary to obtain material suitable for analysis. Much of the bementite rock, however, contains but a relatively small amount of other minerals and, therefore, its properties are essentially the same as those of the selected material to be described The microscope shows the principal associated minerals to be quartz, rhodonite, and a carbonate near calcite and manganiferous calcite (n = 1 660 to 1.705), these minerals being intergrown with the bementite and also deposited in veinlets that cut it.

Locally the bementite rock is cut by veinlets, visible to the unaided eye, that contain one or more of the minerals quartz, calcite, manga-

nocalcite, rhodonite, rhodochrosite, barite, and manganophyllite. At the Apex mine a dense, hard, fine-textured, dark green to black material composed chiefly of manganese oxides forms numerous irregular streaks and bunches that are inclosed by the bementite rock. Under the microscope thin sections of this material show an irregular frame-work or skeleton of transparent bementite imbedded in the opaque oxides. The boundaries between the silicate and the oxides are sharp and the two appear to be of contemporaneous origin. The mineral species of the oxides has not been determined.

A rather striking local feature of the bementite rock is its association with native copper. At the Black and White mine this metal is disseminated as fine specks and flakes through a considerable body of the bementite rock to which it imparts a noticeable red color. Similar, though less abundant, occurrences of copper were observed at Ginnett's prospect and a few places elsewhere. Very small amounts of chalcocite were also observed in specimens from the Black and White and other deposits in that vicinity.

Some specimens of the bementite rock are cut by thin veinlets of dark brown to black amorphous neotocite, associated with calcite, quartz and barite

The principal weathering product of the ordinary bementite rock is a soft, dull black, amorphous manganese oxide. Weathered specimens of the copper-bearing rock commonly show a little green copper stain and specimens from the Black and White mine contain in addition bright red coatings composed of felted aggregates of fine prisms of cuprite or chalcotrichite

The source of the manganese of the bementite rock or the form in which it was first deposited is not known. Its distribution along beds of limestone, however, suggests it to be of sedimentary origin, and the character of the deposits and of the rocks that inclose them indicates the bementite to be a product of regional metamorphism.

The appearance of some thin sections makes it seem probable that the bementite was derived from a granular mineral, possibly tephroite, that was associated with more or less rhodonite In some specimens veinlets of fresh rhodonite cut the bementite, in others crystals of rhodonite are embedded in the bementite, but these may represent veinlet cuttings and crystals associated with the mineral from which the bementite was derived and the rhodonite may have resisted decomposition. However, none of the minute veinlets of bementite

was observed to cut the embedded rhodonite crystals and it may be that the rhodonite is later than and derived from the bementite. Much of the quartz is clearly later than the bementite and in places the bementite is largely replaced by finely crystalline quartz. Some calcite and manganiferous calcite are also later than the bementite, as is also the copper.

Physical properties

The fresh bementite is light gray or grayish brown in color, has a vitreous luster, and is transparent in splinters, but on weathering the color darkens and the material becomes dull and opaque, even in splinters. The mineral has a hardness of about 6 and a specific gravity of 3.106 It is tough and has a splintery fracture. It is decomposed by hot acid, and fuses easily to a black glass

Under the microscope the mineral is seen to be in felted aggregates of fibers or plates Most of it is very finely crystalline but in some parts the crystallization is coarse and tends to be spherulitic; tiny veinlets of more coarsely crystalline mineral, with elongation across the walls, cut the finely crystalline material

The platy crystals show a perfect cleavage with the acute bisectrix normal to the plates and cleavage The optical character is − and the elongation is therefore + The axial angle is near 0 The indices of refraction are $\alpha = 1.624$, $\beta = 1.647$, $\gamma = 1.647$

Composition

A sample of several grams of bementite that was separated by heavy solutions from the manganese-bearing rock of the Black and White mine and, as shown by the microscope, contained not more than 1 per cent of impurities consisting of calcite and rhodonite, was analyzed by Mr Steiger with the result shown in column 1, table 1 For the purpose of comparison, analyses of bementite from Franklin Furnace are given in columns 2 and 3 of table 1, caryopilite in column 4, and inesite in columns 5 and 6 In table 1 are given the chemical analyses, in table 2 the molecular ratios, and in table 3 the molecular ratios reduced to 100.

1. Bementite, Olympic Range, Washington. Analyst, Steiger.
2. Bementite, Franklin Furnace, New Jersey Analyst, Steiger
3. Bementite, Franklin Furnace, New Jersey Analyst, König.
4. Caryopilite, Pajsberg, Wermland, Sweden. Analyst, Hamberg.
5. Inesite, Dillenberg, Germany. Analyst, Bärwald.
6. Inesite, Pajsberg, Wermland, Sweden. Analyst, Flink

TABLE 1 ANALYSES OF BEMENTITE, CARYOPILITE, AND INESITE.

	1	2	3	4	5	6
SiO_2	39.92	38.36	39.00	36.16	43.92	43.67
MnO	41.58	39.22	42.12	46.46	37.87	37.04
FeO	4.15	4.94	3.75		0.69	1.11
MgO	4.46	3.35	3.83	4.80	0.33	0.15
CaO	0.40	0.62	Trace	0.28	8.40	9.38
ZnO		2.93	2.86			
PbO				0.37		0.77
Alkalies				0.20		
Al_2O_3	1.32	0.96		0.35	0.29	
Fe_2O_3		0.71		1.33		
H_2O-	0.49	0.60	8.44		4.54	7.17
H_2O+	7.90	8.01		9.81	4.68	
Cl				0.09		
	100.22	99.70	100.00	99.85	100.72	99.29

TABLE 2. MOLECULAR RATIOS

	1	2	3	4	5	6
SiO_2	665	639	650	603	732	728
MnO	586	550	593	654	533	522
FeO	57	69	52		10	15
MgO	112	84	96	120	8	4
CaO	7	11		5	150	168
ZnO		36	35			
PbO				1		3
Al_2O_3	13	9		3	3	
Fe_2O_3		5		8		
H_2O	439	444	469	545	512	398

TABLE 3 MOLECULAR RATIOS OF TABLE 2 REDUCED TO 100

	1	2	3	4	5	6
SiO_2	35.40	34.61	34.30	31.10	37.59	39.62
MnO[a]	40.55	40.62	40.95	40.22	35.98	38.74
H_2O	23.36	24.07	24.75	28.12	26.28	21.64
Al_2O_3	0.69	0.70		0.56	0.15	
	100.00	100.00	100.00	100.00	100.00	100.00

[a]Under MnO have been summed up the molecular ratios of MnO, FeO, MgO, CaO, ZnO, and PbO

The average molecular ratio of the three analyses of bementite is $40.7MnO.24.1H_2O.34.8SiO_2$, and agrees very nearly in composition with the formula $8MnO.5H_2O.7SiO_2$.

Written in the rational form this formula becomes 8Mn.10 H.7Si. 27O or $5MnH_2SiO_4.Mn_2SiO_4.MnSiO_3$.

Leaving out water leads to the rather more simple rational formula $8Mn.7Si.22O.5H_2O$, or $6MnSiO_3.Mn_2SiO_4.5H_2O$.

Identity of bementite and caryopilite.

The distinction between bementite and caryopilite has been based

TABLE 4. PROPERTIES OF BEMENTITE AND RELATED MINERALS.

	Bementite New Jersey	Bementite Washington	Caryopilite Sweden	Inesite	Ectropite
Form ...	Orthorhombic, radiated, foliated.	Felted masses radiating, platy.	Felted masses radiate-fibrous.	Triclinic fibrous.	Monoclinic, tabular (100) elongated *b*.
Cleavage .	3 pinacoids with different perfection.	Resembles sericite, micaceous.	Micaceous	(010) perfect. (100) less so.	
Hardness.	Soft.	6	3 to 3.5	6	4
Sp. gr....	2.981	3.106	2.83 to 2.91	3.029	2.46(?)
Fusibility.	Fuses readily to a black glass.	Fuses easily to a black glass.			
Solubility	Dissolves in hot HCl without gelatinization	Decomposed by hot acid	Easily soluble in strong acid	Soluble in acid.	
Optical character	—	—	—	—	—
2E......	Near 0.	Near 0	Near 0	57°	Large
Optical orientation	X normal to plates.	X normal to plates.	X normal to plates.	X nearly normal to (010).	Y = *b*. Z somewhat inclined to normal to tablets
α	1.624	1.624	1.603	1.609	
β	1.650	1.647	1.632	1.636	1.625
γ	1.650	1.647	1.632	1.644	
$\gamma-\alpha$	0.026	0.023	0.029	0.035	Weak to moderate

largely on the difference in their chemical composition, but an examination of the analyses and molecular ratios of the two as shown in tables 1 and 2 casts some doubt on this distinction, especially as the analysis of caryopilite is reported to have been made on material not entirely pure.[8] The analyses of caryopilite show somewhat less silicate and somewhat more water and for the bases higher MnO and correspondingly lower FeO than the bementite. The bementite from Franklin Furnace carries considerable zinc. The optical and other physical properties of the two minerals as seen in table 4 show conclusively their identity. The bementite from Franklin Furnace is said to be soft, and the caryopilite is said to have a hardness of 3 to 3.5, while the massive bementite from Washington has a hardness of about 6. The low hardness of the first two may be only apparent and due to the friable character of the material. In view of the close similarity in other optical properties, the somewhat lower in-

[8] Quoted, DANA. *System of mineralogy*, p 704.

dices of refraction of the caryopilite are not sufficient to cast any serious doubt on the identity of the two minerals. The name bementite has the priority, and should be retained for the species.

The composition of the inesite and ectropite is much like that of bementite, but their other properties are sufficiently different to distinguish them.

NEOTOCITE.

Occurrence and properties

The neotocite is present in small veinlets cutting the bementite. It is brown to black, has a clear, resinous luster, and a conchoidal fracture. It is brittle and has a hardness of about 4. Under the microscope it is clear red-brown in transmitted light, isotropic, and has an index of refraction varying from 1 45 to 1 50 and averaging about 1.47. For comparison, neotocite from Sweden was examined. It is black, has a conchoidal fracture, and a vitreous luster and looks like coal. It is brown in powder and in transmitted light under the microscope is clear brown. In part it is isotropic with an index of refraction varying from 1.53 to 1.56, in part it is birefractory with a mean index of refraction varying from 1 54 to 1 58 and a birefringence of about 0.02 The birefractory part is clearly crystallized from the amorphous part and its variable properties are probably due to incomplete crystallization giving submicroscopic admixed amorphous material The crystalline part is probably bementite The name neotocite should be confined to the amorphous mineral having the approximate chemical composition $MnO.SiO_2.nH_2O$ while bementite should be applied to the crystalline mineral ($8\ MnO.7\ SiO_2\ 5\ H_2O$). In common with most amorphous minerals, the composition of neotocite is much less uniform than is that of the crystalline form, bementite

Composition

A chemical analysis made of powder separated from admixed quartz and calcite by heavy solution and carrying a small amount of impurities is shown in tables 5 and 6.

1. Neotocite, Olympic Range, Washington. Analyst, Steiger.
2 and 3. Neotocite, Gestrickland. Analysts, Cleve and Nordenskiold.
4 and 5. Stratopeite, Pajsberg Analysts, Cleve and Nordenskiöld
6. Hydrated manganese silicate, near neotocite, from Dillenberg mining region, Germany, described by A. Schneider.[4]

The mineral dissolves readily in 1 : 1 hydrochloric acid with sep-

[4] Jahrb. Preuss Landesanstalt, 472 et seq 1887.

aration of sandy silica. The figures shown in table 6 roughly suggest a ratio of R″O to SiO_2, of 1 : 1, with a variable quantity of water. However, the chemical composition must be considered very doubtful.

TABLE 5 ANALYSES OF NEOTOCITE, STRATOPEITE, AND A MINERAL NEAR NEOTOCITE

	1	2	3	4	5	6
SiO_2	37 15	35 79	34 38	35 05	35 83	35 64
Al_2O_3	2 58[a]	10 90	1 57			2 59
Fe_2O_3			18 58	1 36	8 20	3 02
MnO	37 00	20 51	22 67	38 49	29 37	39 26
MnO_2	2 03[a]					
FeO		13 93	2 88			
MgO	2 82	2 44	2 50	5 27	8 66	1 31
CaO	2 80	0 52		0 47		1 75
H_2O+	14 07	8 48	9 30	9 81	10 03	13 94
H_2O-		7 29	8 07	6 91	6 08	
CO_2	2 10					0 60
PbO				3 31	2 13	
	100 61	99 86	99 95	100 67	100 30	98 11

[a] Part or all of the iron may be present as FeO in which case a correspondingly large part of the manganese will have the form of MnO_2.

TABLE 6 MOLECULAR RATIOS REDUCED TO 100

SiO_2	30 3	28 0	27 4	26 6	27 3	29 6[b]
R_2O_3	3 5	3 2	6 3	0 4	2 3	2 2[b]
R″O	28 0	26 3	20 2	31 7	29 4	29 9[b]
H_2O	38 2	41 9	46 1	41 3	41 0	38 3[b]
	100 0	100 0	100 0	100 0	100 0	100 0

[b] Ratios after deducting calcium carbonate equivalent to CO_2

PALEONTOLOGY.—*Shell regeneration in a Pennsylvanian brachiopod.*[1] W. ARMSTRONG PRICE, West Virginia Geological Survey. (Communicated by Sidney Paige)

The accompanying photograph, figure 1, shows an area of abnormal sculpture upon the interior surface of a pedicle valve of *Derbya crassa* (Meek and Hayden). The specimen consists merely of the impression of the interior of the valve in a fine-grained, calcareous sandstone. It was associated with numerous impressions[2] of normal shells of this species and with other marine invertebrates.

[1] Published with the permission of the Superintendent of the West Virginia Geological Survey Received December 13, 1920

[2] In gray, sandy shale collected by Mr. DAVID B REGER, from the Kanawha Black Flint horizon of the Kanawha Group of the Pottsville Series near Summit Station, Webster County, West Virginia

1. *Description of abnormal sculpture.*—The area of abnormal sculpture extends from the front margin inward, beyond the center of the shell, for about three-fifths the height and is lobate in outline. It is expanded in the central region where it is sharply defined and has a semicircular border. The lateral borders are somewhat irregular and abnormal sculptural elements (costae) are superimposed upon the normal sculpture in these regions.

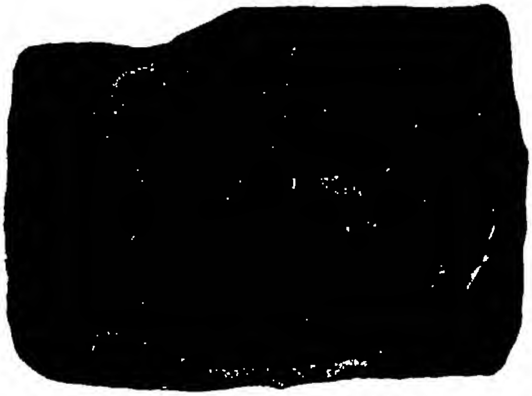

Fig 1 Impression of the interior of a pedicle valve of *Derbya crassa* (× 1⅓) showing an area of abnormal sculpture From the collection of West Virginia Geological Survey, locality 203

The megascopic sculpture of the abnormal area consists of two elements Radiating costae of normal size extend inward from the front margin where they are parallel to each other and are rather evenly spaced at the normal interval for this portion of the shell Slight irregularities in spacing appear The costae diverge inward, the divergence being accelerated in amount beyond the first undulation of growth They increase irregularly in number toward the central region of the shell by the interpolation of smaller costae in such a manner as to produce a fasciculate distribution Both the fasciculate design and the irregularity of the interpolation are abnormal in this species.

The undulations of growth of the normal portion of the shell which intersect the abnormal lobe are continued with unequal distinctness across it

Faint transverse lines, sharply convex toward the back, cross the costae at three points, each originating just beyond one of the growth undulations of the normal portion of the shell They appear to be weak undulations of growth.

The minute granular projections which covered the interior surface of the shell were finer upon the abnormal area than upon the normal shell.

The abnormal lobe has the appearance of a patch placed over a hole of somewhat irregular outline and slightly overlapping the edges

of the shell around the hole. Along the overlapped margin the costae are arranged in a cross-hatched design. It is possible that the original break was much smaller than the lobe of reversed sculpture and it may possibly have been subcircular in outline. Along a portion of the inner and lateral borders the "patch" appears to have overlapped the edges of the break and to have failed to meet the shell smoothly where a gaping crack in the mold appears to denote an irregular ridge which joined the two

2. *Origin of abnormal lobe by regeneration* —The irregularity of the sculpture of the "patch" and its lack of resemblance to that of any of the associated organisms exclude the possibility of its being merely a portion of another shell pressed against the shell of the derbya or adhering to it. It seems most certainly to be an instance of regeneration, or replacement of a broken portion of the shell. The mantle must also have been damaged by the breaking away of the shell and this injury probably supplied the stimulus which brought about the regenerative growth The new growth was thus partly a pathologic phenomenon

3 *Origin of the injury to the shell* --How such a break in the shell may have been caused is not altogether clear. The absence of pebbles and coarse sand in the sediment which enclosed the shell denotes comparatively quiet waters and eliminates the likelihood of its having been caused by the pounding of shells, or shells and stones, by wave action The break appears to have been irregular in outline, and unlike the neat round holes drilled in modern shells by boring snails It is possible that an enemy among the fish was responsible for the injury

4 *Mode of regenerative shell growth* —From the inward divergence of the costae of the regenerated shell it seems likely that the new shell material grew in the direction of divergence across the break and that the growth did not begin simultaneously all over the damaged area. Increase in extent in the normal shell is in a forward direction, and it is probable that, as in the case of the Pelecypoda, as the thickened margin of the mantle is advanced by mantle growth it deposits the larger bulk of the shell material. In the case of the shell which we are studying, it would appear that the direction of growth was reversed. Since we have no way of knowing the extent to which the mantle was damaged we cannot determine the method by which it replaced the shell. It is conceivable that the thickened margin may

have become inverted by reason of the pathologic condition of the mantle and that it reformed the shell by inward growth.

By whatever means accomplished, a layer of new shell substance was spread across the break, overlapping the edges of the old shell, and was deposited in part upon its inner surface.

While the regenerative growth appears to have been abnormal in direction and in the pattern of the resulting sculpture, yet the costae are normal in size and only slight irregularities in spacing were produced.

5. *Rate of regenerative shell growth.*—The rate of shell replacement was sufficiently rapid to complete the patching before the death of the animal.

6. *Time of the injury.*—It may properly be inquired whether the supposed break in the shell occurred before or after the shell had attained its present height It seems possible that the break may have taken place when the shell had grown only to the last undulation of growth posterior to the present front margin, or to some point between these two lines. The unbroken continuity of the costae of the "patch" up to the present margin without the interpolation of new costae anteriorly suggests that the shell did not grow appreciably in length after the "patch" was completed A slight anterior divergence of the costae of the "patch" at the border of the present margin may indicate a little forward growth. If such growth did occur, it may have taken place while the regeneration was in progress

There appears to be no indication as to whether the injury was sufficient to affect the rate of general shell growth as the shell is within the limits of the common adult size for the species

Summary of conclusions.—The impression of a pedicle valve of *Derbya crassa* from the Pottsville Series shows a lobate area upon the interior surface in which the normal direction of costal divergence is reversed.

1. The costae of this lobe are fasciculate, a feature foreign to the species. The inwardly diverging costae overlap the normal costae in places. Other minor details of abnormal ornamentation are noted.

2. The abnormal lobe is not a portion of a foreign shell but was regenerated by the animal following a break in the shell. The mantle also was probably damaged.

3. The origin of the injury to the shell is problematical. The enclosing sediment was deposited in quiet waters. If the injury was caused by an enemy of the brachiopod, the form of the "patch" gives

no clue to its identity. It is suggested that a fish may have been responsible for the damage.

4. The direction of costal divergence is taken as the direction of progressive shell growth in the regenerated area. The precise mode by which the shell was rebuilt is obscure.

5. Regenerative growth was sufficiently rapid to complete the "patch" before fatal damage was done to the exposed animal.

6. The injury probably occurred when the shell had very nearly reached its present size, or at least had reached the first growth undulation posterior to the margin.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY OF WASHINGTON

835TH MEETING

The 835th meeting was held at the Cosmos Club, April 24, 1920, with President SOSMAN in the chair and 40 persons present. The program was as follows.

W. H. SOUDER and C. G. PETERS: *Physical properties of dental materials* (presented by Mr. Souder). This paper, which was illustrated by lantern slides, has since been published in full in *Dental Cosmos* for March, 1920. It was discussed by Messrs. A. W GRAY, WHITE and HUMPHREYS.

H. A. MARMER: *Results of recent tidal current investigations.*

In the past few years, current observations have been secured from the Light Vessels stationed on the Atlantic and Pacific coasts of the United States, from five to forty miles offshore The instruments employed were necessarily of the simplest character A log line, a fifteen-foot current pole, a sandglass or stop watch, and a pelorus constituted the whole outfit. Observations were made hourly, both night and day.

The results of these observations show that on the Atlantic coast, in the inland waters and close inshore along the coast, the tidal currents are of the simple rectilinear or reversing type; that is, the flood runs for a period of about six hours in one direction and the ebb for a like period in the opposite direction. Also, the two floods and the two ebbs of the tidal day are very nearly alike. The curve of velocities, therefore, is approximately a sine curve and the times of slack, and of flood and ebb strengths bear a nearly constant relation to the times of local high and low water.

Farther offshore, the currents on the Atlantic coast become more complex. Instead of flowing in the same general direction for a period of six hours, and in the opposite direction for a like period, the current constantly changes directions, clockwise, at such a rate that in a little over twelve hours it will have veered completely around the compass. That is, the current is rotary instead of being rectilinear. In a tidal day, therefore, the curves representing the velocity and direction of the current will appear as two ellipses, bearing a close resemblance to each other in every respect.

The rotary current is distinguished from the rectilinear current not only by the constant change in direction, but also by a difference of behavior in the change of velocity. In the rectilinear type, the current starts from a slack or period of no motion and gradually increases until it attains a maximum, after which it decreases to another slack. In the rotary current, there is no period of slack; the current is running at all times. There is, however, a maximum and a minimum velocity, corresponding to half the major and minor axes of the ellipse representing the curve of velocities. This rotary type of current having a circuit of approximately twelve hours and the two circuits of the day being very much alike, is typical of the offshore current of the Atlantic coast of the United States.

On the Pacific coast somewhat similar conditions obtain. The currents close inshore are of the rectilinear type, while those offshore are of the clockwise rotary type. However, the two current curves of a tidal day are generally quite different. This is due to the diurnal inequality present in the tides of the Pacific coast.

The diurnal inequality is largely a function of the moon's declination. It therefore varies throughout the month, being at a minimum when the moon is on the equator and a maximum when the moon is furthest north or south. The effect of this on the rotary current is to make the two circuits of a tidal day very nearly alike when the moon is on the equator, but quite unlike when the moon is farthest north or south.

The paper was illustrated with lantern slides, and was discussed by Messrs. WHITE, C. A. BRIGGS, TUCKERMAN, O. S. ADAMS, HUMPHREYS, BEALL, MCKEEHAN, BOWIE and HAWKESWORTH.

In reply to questions by Messrs. WHITE, HUMPHREYS and ADAMS, it was brought out that the relation of strength of current to time of high and low water varies greatly; that the motion of tidal currents is in the same direction from surface to bottom, and that the direction of rotation of the rotary current is conditioned by local causes.

830TH MEETING

The 830th meeting was held at the Cosmos Club, May 8, 1920, with President SOSMAN presiding and 30 persons present. The program was as follows:

F. B. SILSBEE *Physics of the high-tension magneto.*

Magnetos for igniting internal combustion engines have been gradually evolved in parallel with the development of the engines on which they are used, and the present high-speed, high-compression engines have led to the development of the present so-called "high-tension magneto" This is an extremely complex electrical system and the complete details of its operation are relatively little understood even by the manufacturers of the apparatus

The speaker described the results of a study of this type of device carried out at the Bureau of Standards in connection with the developing and testing of aircraft engines The results of this study have been published in Report No 58 of the National Advisory Committee for Aeronautics.

The cycle operations of the magneto can be divided into a number of periods during each of which the electrical phenomena proceed under fairly definite conditions, but each of which is separated from the one preceding and the one following it by a change of conditions, such as the opening of the primary contact or the breaking down of the spark gap. Some of these periods, such as the building up of the primary current can be studied by means of the oscillograph, but others, such as the rise of voltage after "break" are so short that this instrument cannot record the phenomena.

The paper was illustrated by a number of oscillograms showing both normal and abnormal performance of ignition apparatus.

Discussion: The paper was discussed by Messrs. C. A. BRIGGS, WHITE, SLIGH and SOSMAN.

C. NUSBAUM: *The magnetic reluctivity relationship as related to certain structures of an eutectoid carbon steel.*

The magnetic reluctivity ρ, defined as the ratio of the magnetizing force to the induction, has been shown by Kennelly to be related to the magnetizing force by the relationship

$$\rho = \alpha + \beta H \qquad (1)$$

but for high inductions this has to be modified to

$$\rho_0 = \frac{H}{B-H} = \alpha_1 + \beta_1 H \qquad (2)$$

where ρ_0 is the metallic reluctivity and $B-H$ is the metallic induction or flux carried only by the molecules of the metal. For pure and well-annealed materials the reluctivity line is a straight line while in the more or less impure commercial materials the reluctivity line while approximately a straight one has generally a point where its slope changes. Since the change in the slope of the line is in general greater with the increase in impurity of the material the cause is evidently a lack of homogeneity; *i. e.*, the presence in the substance as aggregates or inglomerates of materials of different magnetic characteristics. Although the arrangement of the constituents in a carbon steel is generally a random one, it may be considered as combinations of any of the three simple arrangements, *viz.*, (*a*) the parallel, (*b*) the series, and (*c*) the spheroidal.

In the experiments described in the present paper, two specimens of an eutectoid carbon steel (0.85 per cent carbon) were selected and turned down to a uniform diameter of approximately 7 mm Each of these specimens was quenched from 800° C., one in oil, the other in water, and then carefully ground down to 6 mm Each specimen was then cut in halves designated A and B, which were then drawn alternately to increasingly higher temperatures up to 700° C Normal induction curves, up to values of the magnetizing force as high as 2500 gauss, were determined after each operation.

Curves for a few of these heat treatments were shown. Other magnetic properties shown graphically were (*a*) the values of the induction for constant values of the magnetizing force as plotted against the drawing temperatures; (*b*) the reciprocals of the susceptibility (4π times the reluctivity) as plotted against the magnetizing forces, (*c*) the value of the saturation intensity of the magnetization as plotted against the drawing temperatures; and (*d*) the values of the "magnetic hardness" as plotted against the drawing temperatures. Referring to equation (2) the values of the saturation intensity of magnetization are equal to $\frac{1}{4\pi\beta}$, *i e.*, the reciprocal of the slope of the reciprocal of susceptibility line The values of the "magnetic hardness" are the values of α; *i. e.*, the intercept on the axis of ordinates

These two characteristics are those with which this paper is most concerned, since they show more than any others the transformations which take place in the steel as a result of the heat treatment. It is found that in a region included by the quenched condition and a drawing temperature of 230° C., in which the specimen is known to be martensitic in structure there is a distinct bend in the reluctivity lines and consequently there are two values of the saturation intensity of magnetization and the "magnetic hardness" as calculated from the upper and lower portions of the reluctivity line. In the range of drawing temperatures bounded by 230° C. and 470° C., in which the steel is troostitic, the reluctivity line has but one slope, hence the saturation intensity of magnetization and the "magnetic hardness" each have but one value for a given drawing temperature and the material is magnetically homogeneous. Beyond 470° C. the reluctivity line again has a bend and

the material is non-homogeneous, this inhomogeneity being due to the increasing size of the aggregates and to their approaching stratification.

The paper was illustrated by lantern slides.

Discussion: This paper was discussed by Messrs. SOSMAN, C. A. BRIGGS, SILSBEE, TUCKERMAN, and HUMPHREYS.

S. J. MAUCHLY, *Recording Secretary.*

CHEMICAL SOCIETY

(Local Section of the American Chemical Society.)

268TH TO 300TH MEETINGS

The 268th meeting was held at the Cosmos Club on February 8, 1917. F. A. MCDERMOTT presented a paper on *Some experiments on the growth of yeast in synthetic media.* The proposed "code of ethics" for the chemical profession was discussed. Messrs. HILLEBRAND, BUCHBINDER and others informally discussed current experience with so-called "analyzed chemicals."

The 269th meeting was held at the Cosmos Club on March 8, 1917. Coordination of action among the local sections of the American Chemical Society was discussed informally. The regular program was as follows: F. B. LA FORGE: *Sedoheptose, a new sugar from* Sedum spectabile. E. C. MCKELVY. *Composition and testing of commercial liquid ammonia.* D. R. HARPER, 3D. *Work on the thermodynamic properties of ammonia at the Bureau of Standards.*

The 270th meeting was held at the Cosmos Club on April 12, 1917. Program: W. M. CLARK· *Indicators and the hydrogen electrode in the service of bacteriology.* J. N. CURRIE. *Citric acid fermentation of* Aspergillus niger. L. E. WISE *Elementary organic analysis by micro-combustion methods.* F. R. BICHOWSKY. *The electrometric determination of zinc.*

The 271st meeting was held at the Cosmos Club on April 20, 1917. Prof. MARSTON T. BOGERT of Columbia University, Chairman of the Chemistry Committee of the National Research Council, spoke upon *Chemistry and the war.* The aims and purposes of the Research Council in peace and war were discussed with special reference to chemistry.

The 272d meeting was held at the Cosmos Club on May 10, 1917. Program· H. D. GIBBS: *Catalysis of some oxidation reactions.* J B. TUTTLE and L. YUROW· *Direct determination of rubber by combustion of the nitrosite.* I. K. PHELPS and H. E PALMER: *Separation and identification of lactic acid in biological mixtures.*

The 273rd meeting was held at the Cosmos Club on October 11, 1917. Program· W. D. COLLINS. *Arsenic in sulphured food products.* C. C. MCDONNELL: *Investigations on lead arsenate.* F. P VEITCH. *Investigations of shoe soling material.*

The 274th meeting was held at the Cosmos Club on November 8, 1917, and was devoted to the annual election of officers for the ensuing year. The election resulted as follows· *President,* FREDERICK B. POWER, *Secretary,* E. C. MCKELVY; *Treasurer,* F. P. DEWEY; *Members of Council of American Chemical Society,* C. O. JOHNS, A. SEIDELL, F. W. SMITHER, R. B. SOSMAN; *Members of Executive Committee,* F. C. COOK, P. B. DUNBAR, E. H. INGERSOLL, M. J. INGLE, E. C. LATHROP, F. A. WERTZ.

The 275th meeting was held at the Cosmos Club on November 19, 1917. Prof. C. A. KRAUS lectured on *Laboratory methods and apparatus.*

The 276th meeting was held at the Cosmos Club on December 13, 1917. Program: ATHERTON SEIDELL: *Utilization of the adsorptive power of fullers' earth for chemical separation.* OSWALD SCHREINER: *The potash situation in relation to food crops.*

The 277th meeting was held at the Cosmos Club on December 18, 1917. Prof. W. D. BANCROFT lectured on *Contact catalysis.*

The 278th meeting was held at the Cosmos Club on January 10, 1918. The retiring president, C. S. HUDSON, delivered an address on *American sources of supply for the various sugars,* illustrated with samples of sugar-bearing products and purified sugars.

The 279th meeting was held at the Cosmos Club on February 14, 1918. Program: GRINNELL JONES· *The work of the Tariff Commission and its relation to the chemical industries.* D. B. JONES *The hydrolysis of kafarin.*

The 280th meeting was held at the Cosmos Club on March 14, 1918. Program: J. F. NORRIS: *The activity of certain elements in carbon compounds.* H. A. LUBS. *Determination of the products formed in the chlorination of toluene.* C. J. WEST: *The chemistry of the unsaturated lipoids.*

The 281st meeting was held at the Cosmos Club on April 11, 1918. Program· C. W. MERRILL *The ammonia program for 1918.* E. C. McKELVY and A. ISAACS· *Non-condensing gas formation in ammonia absorption machines: its cause and prevention.*

The 282d meeting was held jointly with the Washington Academy of Sciences at the Interior Department. Prof. A. A. NOYES lectured on *The nitrogen problem in relation to the war.* The lecture has been published in the *Journal* of the ACADEMY.[1]

The 283d meeting was held at the Carnegie Institution on November 14, 1918. Program ROGER ADAMS *The preparation of organic chemical reagents.* C. L. ALSBERG *The value of a museum of chemical compounds.* Reports on the general meeting of the Society at Cleveland, Ohio, were presented.

The 284th meeting was held at the Carnegie Institution on December 12, 1918, and was devoted to the annual election of officers. The following were elected *President,* ATHERTON SEIDELL, *Secretary,* E. C. McKELVY; *Treasurer,* F. P. DEWEY, *Members of Council, American Chemical Society,* C. O. JOHNS, JOHN JOHNSTON, F. B. POWER, F. W. SMITHER, R. B. SOSMAN, F. A. WERTZ; *Members Executive Committee,* W. BLUM, F. C. COOK, P B. DUNBAR, F. F. FITZGERALD, M. J. INGLE, R. C. WELLS.

A series of reconstruction proposals, prepared by the local council, were approved for submission to the December meeting of the Council of the general Society.

The 285th meeting was held jointly with the Washington Academy of Sciences at the Carnegie Institution, on Thursday, January 9, 1919. The retiring president of the Chemical Society, Dr F. B. POWER, gave an illustrated address on *The distribution and character of some of the odorous principles of plants.* This has been published elsewhere.[2]

The 286th meeting was held at the new assembly hall of the Cosmos Club on January 23, 1919. Program: W. H SMITH *Airplane dopes.* R. N. HARGER: *The preparation of metol.* J. D. DAVIS. *The removal of phosphine from ammonia made from cyanamide.* The appointment of the fol-

[1] This JOURNAL 8: 381–394. 1918.

[2] Journ. Ind Eng. Chem. 11: 344–352. 1919.

lowing committees was announced. *Programs:* J. C. HOSTETTER, W. M. CLARK, F. F. FITZGERALD, L. J. GILLESPIE, C. O. JOHNS, G. A. RANKIN, E. R. WEAVER, R. C. WELLS, L. E. WISE; *Entertainment:* F. F. FITZGERALD, F. R. v. BICHOWSKY, P. J. DONK, A. M. HEINZELMAN, H. A. LEPPER, J. H. SHRADER.

The 287th meeting was held at the Cosmos Club on February 13, 1919. Lieut. Col. A. H. WHITE lectured on *The present status of the nitrate industry in the United States.*

The 288th meeting was held at the Cosmos Club on February 27, 1919. Dr. JOHN JOHNSTON lectured on *The National Research Council.* A general discussion followed on the proposed plans of the Society for compendia of chemical and physical constants and for technologic and scientific monograms.

The 289th meeting was held at the Cosmos Club on March 13, 1919. Col. A. B. LAMB lectured on *Chemical protection against poisonous gases.*

The 200th meeting was held jointly with the Washington Academy of Sciences at the Cosmos Club, on March 27, 1919. Dr. ARTHUR L. DAY lectured on *Optical glass.* An abstract of the lecture has been published in the *Journal* of the ACADEMY [3]

The 291st meeting was held at the Cosmos Club on April 15, 1919, and was devoted to reports on the general meeting of the Society at Buffalo, New York, April 7–10, 1919.

The 292d meeting was held at the Bureau of Standards on April 24, 1919, and was preceded by a dinner served at the dining-room in the West Building. Dr. W F. HILLEBRAND described the plans and construction of the new Chemistry Building of the Bureau The remainder of the evening was devoted to an inspection of the building and apparatus.

The 293d meeting was held at the Cosmos Club on May 8, 1919. Program: CHARLES L. PARSONS: *The oxidation of ammonia.* ALLERTON S. CUSHMAN: *The chemistry of military primers.*

The 294th meeting was held at the Cosmos Club on May 22, 1919. Program: H. D. GIBBS *The work of the color laboratory of the Bureau of Chemistry.* K. P MONROE: *The commercial preparation and some of the commercial applications of the enzyme invertase.*

The 295th meeting was held at the Cosmos Club October 9, 1919. Program E. K. NELSON: *Vanillyl acyl amides.* A. J FINKS *Growth experiments with the proteins of the navy bean.* L. L. STEELE and F. M. WASHBURN: *A new hexabromide method for linseed oil* W. M. CLARK and F. F. ZOLLER: *Manufacture of commercial casein.*

The 296th meeting was held at the Cosmos Club on October 23, 1919 Program. R. E. ROSE, of E. I. Du Pont de Nemours and Company: *The status and prospects of the dye industry in the United States.*

The 297th meeting was held at the Cosmos Club on November 13, 1919. Program. E. T. WHERRY *Crystallography in the service of the chemist.* E. T. ALLEN *A new method for the study of fumaroles*

Officers for 1920 were elected, as follows. *President,* C. O. JOHNS; *Secretary,* E. C. McKELVY; *Treasurer,* F. P. DEWEY, *Members of Council, American Chemical Society,* W. D. COLLINS, F. B. POWER, A. SEIDELL, F. W. SMITHER, R. B. SOSMAN; *Members Executive Committee,* L. H. ADAMS, F. C. COOK, P. B. DUNBAR, M. J. INGLE, W. W. SKINNER, R. C. WELLS.

[3] This JOURNAL 9: 603–604 1919.

The 298th meeting was held at the Cosmos Club at 8 p.m. on Tuesday, November 25, 1919. Dr. CHARLES H. HERTY, who had just returned from Europe, where he had been sent with the approval of President Wilson, to secure for the American dye consuming industry a six months' supply of vat dyes from stocks held by the Reparations Commission under the terms of the Peace Treaty, addressed the Society on his interesting experiences

The 299th meeting was held at the Cosmos Club at 8 p.m. on Thursday, December 11, 1919. Mr. R. S McBRIDE was appointed Secretary *pro tem.* Program· S. L JODIDI· *The quantitative determination of amino acids, polypeptides, and similar compounds, and their relation to certain plant diseases* (illustrated). C. S. CRAGOE, C H. MEYERS, and C. S TAYLOR: *The vapor pressure of ammonia* (illustrated).

The latter part of the meeting was devoted to an appreciation of the life and work of the late Secretary of the Society, Mr. E. C. McKELVY, who died on November 29 from burns received in an accident at the Bureau of Standards

The 300th meeting was held at the Cosmos Club at 8 p m on Thursday, January 8, 1920 Mr J B REED, of the Bureau of Chemistry, was elected Secretary to succeed the late E. C. McKELVY.

The meeting was planned as a commemorative meeting, and the papers presented were concerned with the organization and early history of the Society. H. W WILEY, formerly chief of the Bureau of Chemistry, F. W CLARKE, of the Geological Survey, and F. P. DEWEY, of the Bureau of the Mint, gave informal talks, illustrated with early programs, letters, and photographs R S McBRIDE, of the Bureau of Standards, outlined the work of the Society during the past ten years.

J. B REED, *Secretary*

SCIENTIFIC NOTES AND NEWS

The Pick and Hammer Club met at the Conference Room of the Geological Survey on December 18, 1920, at 8 p.m. The following papers were presented: A. H. BROOKS. *The Society of Economic Geologists; its origin and its proposed scope of work.* DAVID WHITE: *Recent meetings and scope of some kindred societies.* W. C MENDENHALL: *Land classification work under the recent leasing bill.*

The Washington Branch of the Society of American Bacteriologists met on December 20 at the District Building. Papers were presented by CHARLES THOM, RUTH B. EDMONDSON, C L. MCARTHUR, W. D. BIGELOW, and P H. CATHCART.

The Agricultural History Society met on December 16 at the Public Library. G. K. HOLMES spoke on *The history of tobacco* and O. C. STINE on *Agriculture of the Plymouth Colony.*

Engineering Council held its last meeting in Washington on December 16, having recommended to its parent body, the United Engineering Society, that it be discharged from service and that its current and unfinished business be referred to the new American Engineering Council, the governing body of the recently organized Federated American Engineering Societies.

Dr. W W. COBLENTZ of the Bureau of Standards has been awarded the Janssen medal of the Académie des Sciences, Institute de France, for his work on the infra-red radiation from terrestrial sources and from stars.

Mr. ALFRED N. FINN, who resigned from the Bureau of Standards in 1919, was reappointed to the chemical staff of the Bureau in October.

Mr. F. F FITZGERALD resigned from the staff of the National Canners Association Laboratory in November to accept a position with the American Can Company at 120 Broadway, New York City

Mr. M. G. GULLEY has been appointed assistant geologist in the U. S. Geological Survey, and has been temporarily assigned to assist Mr. F. L. RANSOME in field work in the Oatman District, Arizona.

Mr. WALTER A. HULL, formerly in charge of the work on fire-resistive properties of materials at the Bureau of Standards, has been placed in charge of the work on optical glass in the Division of Ceramics of the Bureau.

Mr. W. E MYER of Nashville, Tennessee, was in Washington in December preparing a report for the Bureau of American Ethnology on his archeological field work of last summer in the Cumberland Valley.

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OF THE
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PHYSICS.—*The compressibility of diamond.*[1] L. H. Adams, Geophysical Laboratory, Carnegie Institution of Washington.

Many of the properties of that remarkable form of carbon, the diamond, are known, but its compressibility has never been measured. The commercial value of a quantity of diamonds sufficient for such a determination is so great that the opportunity for making the determination would seldom present itself. It is not necessary for this purpose, however, that the material be in one piece or even in large fragments although, contrary to what is commonly believed, no apprehension need be felt in subjecting diamonds or any other homogeneous material to the enormous pressures required [2]

It was the writer's good fortune to have at his disposal about 80 grams of diamond chips obtained through Dr. F. E Wright, of this Laboratory, from S. L. Van Wezel, Inc., of New York City.[3] The material was in the form of clear, colorless fragments of various sizes up to one or two millimeters in their largest dimension. A small amount of metallic impurity was found to be present and was removed by treatment with hot nitric acid After being washed with water and dried in the oven, a fraction consisting of about 30 grams of the coarser fragments was separated from the remainder and was used for the measurement of the compressibility.

The method used has been described in a former publication[4] from this Laboratory. Briefly, it is as follows: The material to be investigated is surrounded by kerosene and placed in a cylindrical, heavy-walled, steel bomb, one end of which is closed while in the other end is fitted a piston with a suitable packing. Pressure is applied

[1] Received January 8, 1921.

[2] As long, of course, as the pressure is strictly hydrostatic, that is, uniform in all directions

[3] Our thanks are due to this firm and especially to the President, Mr M S Van Wezel, for their courtesy in lending this material

[4] L. H. Adams and E. D. Williamson, Journ Amer Chem Soc 41: 12–42 1919.

by forcing the piston into the bomb by means of a powerful hydraulic press. In order to determine the compressibility it is necessary to measure the pressure and the decrease in volume. The pressure is measured by means of a small coil of "therlo" wire the resistance of which changes with pressure according to a known relation; and the volume-decrease is determined by the movement of the piston, which is measured with a dial micrometer. Pressures were read to 1 megabar and piston displacements to 0.001 mm. As a means of correcting for the compressibility of the kerosene, an exactly similar series of measurements is carried out with some other substance of known compressibility.

The diamonds were placed in a thin-walled steel capsule, and the comparison body was a Bessemer steel cylinder the volume of which was equal to the volume of the diamonds plus the volume of metal in the capsule. In order to remove any air bubbles which might cling to the diamond fragments, the material, having been placed in the capsule, was covered with kerosene and the whole evacuated.

With the apparatus used the most accurate measurements are obtained in the range from 4,000 to 10,000 megabars.[3] Accordingly, it seemed best to make several series of readings within this range of pressure Readings were taken at 4,000, 6,000, 8,000 and 10,000 megabars. Three separate runs were made with the diamond and two with the steel, but the first series with the diamond was subject to slight irregularities due to trouble with the electrical connections and was therefore neglected in the final calculations. The method for calculating the results and for making the various corrections is described in detail in the paper already referred to.

Various ways of combining the data of the two series for steel and the two series for diamond led to substantially the same result. If the mean of the former be compared with the mean of the latter, the relative decrease in volume, $\frac{\Delta v}{v_0}$, is found to be as shown in table 1.

TABLE 1

DECREASE OF VOLUME OF DIAMOND UNDER PRESSURE

Pressure megabars p	Volume decrease $\frac{\Delta v}{v_0} \times 10^3$	$\frac{\Delta v}{v_0} \times 10^3$ Calc. from equation (1)	Diff
4000	0	0 05	−0.05
6000	1.01	0 93	+0 08
8000	1 81	1 82	−0.01
10000	2 68	2 70	+0 02

[3] 1 megabar = 0 987 atmosphere.

In table 1 the second column shows the "observed" relative decrease in volume corresponding to the pressures given in the first column. The arbitrary zero with reference to the volume change was at 4000 megabars.

The decrease in volume was assumed to be a linear function of the pressure, that is,

$$\frac{\Delta v}{v_0} \times 10^3 = a + b\,(p - p_0) \times 10^{-3}, \qquad (1)$$

and by the method of least squares the values of the constants a and b were calculated from the data in table 1. The value found for b was 0.442, which, multiplied by 10^{-6}, is the difference between β, the compressibility of diamond, and β', that of steel. That is, $\beta' - \beta = 0.44 \times 10^{-6}$. If the compressibility of steel[6] be taken as 0.60×10^{-6} the compressibility of diamond is

$$\beta = 0.16 \times 10^{-6} \text{ per megabar.}$$

This value is estimated to be correct within $\pm\, 0.02 \times 10^{-6}$.

From this result it is evident that the compressibility of diamond is remarkably low; indeed, of all substances whose elastic behavior is known, diamond is by far the most incompressible. Its nearest competitor, tungsten, is nearly twice as compressible ($\beta = 0.27 \times 10^{-6}$), and the majority of solids decrease their volume more than ten times as much for a given increment of pressure. If a diamond were buried 100 miles below the surface of the earth the pressure due to the superincumbent rock—a higher pressure than has ever been attained in the laboratory—would decrease the volume only about three-fourths of one per cent.

It is noteworthy that the other modification of carbon, graphite, is much more compressible, the value of β, according to Richards,[7] being 3.0×10^{-6}.

Relation of compressibility to other properties.—Einstein[8] has derived the following equation, involving the compressibility β

[6] Compare P. W. BRIDGMAN, Proc Amer. Acad. 47: 366. 1911. E. GRÜNEISEN, Ann. Phys. (4) 33: 1262 1910.

[7] T W. RICHARDS, Journ. Amer. Chem. Soc. 37: 1646. 1915

[8] A. EINSTEIN, Ann Phys. (4) 34: 170. 1911. The specific heat per gram-atom, C_v of any monatomic solid, according to Einstein, is a universal function of ν/T, thus:

$$C_v = 3R\,\frac{e^{h\nu/kT}\cdot(h\nu/kT)^2}{(e^{h\nu/kT} - 1)^2}$$

R, h and k being universal constants.

*(in absolute units), the atomic weight A, the density ρ, and the vi*bration frequency ν of the atoms:

$$\nu = 3.3 \times 10^{7} A^{-1/3} \rho^{-1/6} \beta^{-1/2} \tag{2}$$

Lindemann,[9] on the other hand, calculates ν from the equation:

$$\nu = 3.1 \times 10^{12} A^{-5/6} \rho^{1/3} T_m^{1/2} \tag{3}$$

in which T_m is the melting point on the absolute scale. Eliminating ν from these two equations, and multiplying by 10^6 in order to change the units of β from cm^2/dyne to cm^2/megadyne, we have.

$$\beta = 1.13 \times 10^{-4} \frac{A}{\rho T_m} \tag{4}$$

This equation closely resembles the empirical equation used by Richards,[10] namely, $\beta = 2.1 \times 10^{-4} \dfrac{A}{\rho^{1.33} (T_m - 50)}$, and yields for many elements values of β which are in fair accord with the observed values. The melting point of diamond is not known, but assuming that it is 4000°, and taking ρ as 3.51, the value of β calculated from equation (4) is 0.10×10^{-6}. As calculated from Richards' formula, the value is 0.13×10^{-6}.

Another equation may be obtained from Grüneisen's formula.[11]

$$\nu = 2.9 + 10^{11} \left(\frac{c_v}{\alpha}\right)^{1/2} A^{-1/3} \rho^{1/3} \tag{5}$$

in which c_v is the specific heat per gram, and α is the cubical expansion coefficient. Eliminating ν from equations (2) and (5) and multiplying by 10^6 as before, we have

$$\beta = 1.29 \times 10^{-2} \frac{\alpha}{c_v \rho} \tag{6}$$

This equation clearly illustrates the fact that low compressibility tends to be accompanied by low thermal expansibility. In using equation (5) or (6) for numerical calculation, however, for the ratio $\dfrac{\alpha}{c_v}$ must be taken its *limiting value* as the temperature is decreased. It may be noted, nevertheless, that if the values of c_v and α for diamond at 25° C. (c_v = 0.12 cal. per g; $\alpha = 3.5 \times 10^{-6}$) be substituted in equation (6), β is found to be 0.11×10^{-6}.

[9] F. A. LINDEMANN, Phys. Zeitschr. 11: 609. 1911.

[10] Op. cit., p. 1653. See also W. D. HARKINS and R. E. HALL, Journ. Amer. Chem. Soc. 8: 209. 1916.

[11] E. GRÜNEISEN, Ann. Phys. (4) 39: 293. 1912.

Another useful relation involving the compressibility is that given by Debye:[12]

$$\theta = \frac{h\nu_m}{k} = \frac{35.74 \times 10^{-4}}{A^{1/3}\rho^{1/6}\beta^{1/2}} \cdot \frac{1}{\phi^{1/3}} \qquad (7)$$

In this equation β is in absolute units, and ϕ is a function of σ, Poisson's ratio,[13] thus:

$$\phi = 2\left(\frac{2}{3} \cdot \frac{1+\sigma}{1-2\sigma}\right)^{3/2} + \left(\frac{1+\sigma}{3(1-\sigma)}\right)^{3/2}$$

Rearranging equation (7), substituting Debye's values for h and k, and expressing β in cm.^{2}/megadyne, we have

$$\beta = 5.5 \times 10^{21}\,\nu_m^{-2} A^{-2/3} \rho^{-1/3} \phi^{-2/3} \qquad (8)$$

The value of ν_m for any element can be calculated from equation (7) provided that the specific heat is known at one or more suitable temperatures, and ϕ can be calculated when σ, Poisson's ratio, is known. Equation (8), then, can be used to calculate the compressibility of any element for which C_v and σ have been measured. For several elements for which these quantities are known the compressibilities have been calculated by equation (8) with the results shown in table 2.

TABLE 2

CALCULATION OF COMPRESSIBILITY FROM SPECIFIC HEAT AND POISSON'S RATIO

Substance	Max. atomic frequency $\nu_m \times 10^{12}$	At. wt. A	Density ρ	Poisson's ratio σ	Compressibility calc. from equation (8) $\beta \times 10^6$	$\beta \times 10^6$ observed
Aluminum	8.2	27.1	2.7	0.34	1.42	1.32
Copper	6.4	63.6	8.9	0.35	0.83	0.75
Silver	4.4	107.9	10.5	0.38	0.92	0.97
Lead	2.0	207.2	11.3	[0.45]	[1.1]	2.2
Diamond	39.2	12.0	3.5	(0.25)	0.16	0.16

The values for ν_m are taken from Debye and those for σ are as given by Gruneisen.[14] Poisson's ratio for diamond has not been measured,

[12] P. DEBYE, Ann. Phys. (4) **39**: 816. 1912. Debye considers that the atoms in a solid are vibrating, not with a single frequency, but with a number of different frequencies, and that the specific heat is a universal function of $\frac{\nu_m}{T}$, ν_m being the maximum frequency. His equation is

$$C_v = 3R\left\{\frac{12}{x^3}\int_0^x \frac{q^3 dq}{e^q - 1} - \frac{3x}{e^x - 1}\right\}$$

in which $x = \frac{h\nu_m}{kT} = \frac{\theta}{T}$, and q is an integration variable.

[13] Strictly speaking, Poisson's ratio has no meaning except with reference to an isotropic or pseudo-isotropic substance.

[14] E. GRÜNEISEN, Ann. Phys. (4) **25**: 847. 1908.

but in accordance with the well-known fact that, in general, σ for hard and highly incompressible substances is approximately 0.25, it has been assumed to have this value The agreement between β calculated and β observed is satisfactory except for lead. Poisson's ratio, however, is a difficult property to measure accurately, and the large discrepancy in the case of lead, as well as the smaller discrepancies for the other metals may, not unreasonably, be ascribed to an error in the values of σ For example, if σ for lead were 0.40 instead of 0.45 as given by Grüneisen, equation (8) would yield a value of β almost exactly equal to the observed value.

Since a small change in σ leads to a large change in β, or, conversely, since a given change in β corresponds to a much smaller variation in σ, this equation may be used to calculate with high precision the value of the important elastic constant, σ, for all those elements for which the compressibility and specific heat are known Thus, granting the validity of the reasoning by which Debye arrived at his formula—the remarkable success of Debye's specific heat formula in accurately representing the variation of specific heat with temperature would seem to substantiate the soundness of his theory— we may state with considerable confidence that Poisson's ratio for diamond is not far from 0 25

In the course of the measurement of the compressibility of diamond the density of the fragments was determined by the pyknometer method and found to be 3 513 at 25° This is in good agreement with the value 3 514 at 18° obtained by Cohen and Olie.[15]

Summary—The cubic compressibility $\frac{1}{v_0} \cdot \frac{dv}{dp}$ of clear, colorless diamond of density 3 513 was measured by comparison with soft steel Assuming the compressibility of steel to be 0 60 $\times$ 10^{-6} per megabar, the compressibility of diamond is

$$0.16 \times 10^{-6} \text{ per megabar}$$

This is the lowest compressibility of any known substance

From a consideration of various formulas expressing the relations connecting compressibility with other physical properties, it appears that the low compressibility of diamond is intimately related to its high melting point, its low expansion coefficient, and its high atomic frequency.

Very accurate values of Poisson's ratio for the various elements might be obtained by Debye's equation if the compressibility and specific heat were previously determined

[15] E. COHEN and J OLIE, JR, Zeitschr Phys Chem 71: 391 1910

ELECTRICAL ENGINEERING —*Oscillograph measurements of the instantaneous values of current and voltage in the battery circuit of automobiles.* G. W. VINAL and C. L. SNYDER, Bureau of Standards.[1]

Performance curves showing the instantaneous demands made upon automobile starting and lighting batteries when cranking the engines have been obtained recently at the Bureau of Standards. These curves were made while preparing specifications for this type of battery for the Motor Transport Division of the War Department. In the course of these experiments additional information was obtained with respect to the operation of the starter system and the engine itself.

In order to measure the rapidly fluctuating values of current and voltage a 3-element oscillograph was used The ordinary film drum was replaced, however, by a camera of special construction. Time was recorded by one element while the current and the battery voltage were measured by the two remaining elements The oscillograph records show the instantaneous values of current and voltage which cannot be obtained with the ordinary indicating instruments

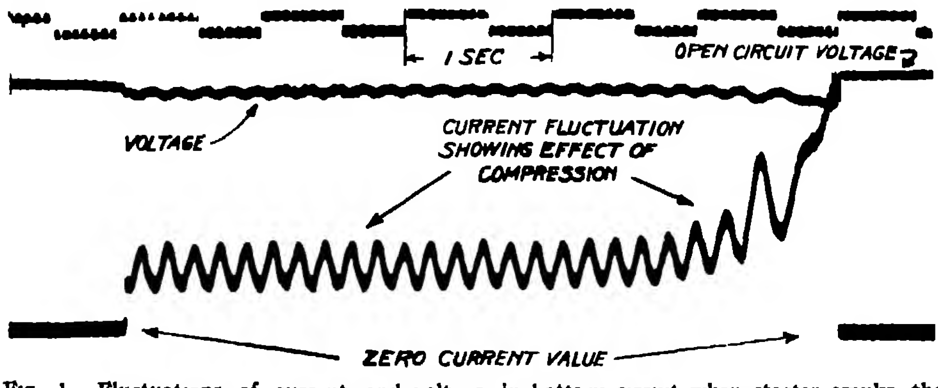

Fig 1 —Fluctuations of current and voltage in battery circuit when starter cranks the engine Initial value of current 125 amperes Four cylinder car 12-volt single unit system Time scale in half seconds at top of record

A series of measurements under various conditions of operation was made upon a number of cars of different makes The records for the various cars show different characteristics which are typical of the design and condition of the engine and starter system. All of the

[1] Published by permission of the Director, Bureau of Standards Received December 22, 1920. The complete paper will be published as Technological Paper No. 186 of the Bureau of Standards

cars were in ordinary running order when the measurements were made.

It is possible to show only two of the records in the present paper. These have been chosen to illustrate the general character of the curves which were obtained from a well-known 4-cylinder car equipped with a 12-volt single unit starting system. Figure 1 shows the fluctuations of current and voltage when the starter was in operation. The initial starting current was about 125 amperes, but decreased rapidly. The pulsating character of the current is due to the compression in the successive cylinders. The minimum values of the voltage correspond with the maximum values of the current The time scale in half seconds is shown at the top of the record

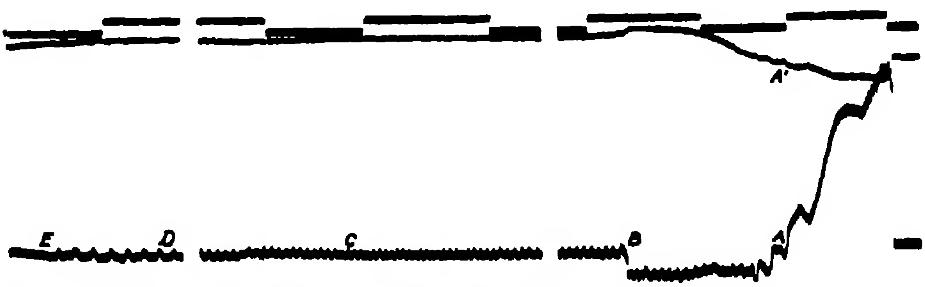

Fig 2.—Starting of the engine, on second compression *A* and *A′* indicate operation of reverse current relay, *B*, release of starter pedal, *C*, charging current, engine speeding, *D*, speed decreased, *E*, ignition cut-off Interruptions in charging current caused by ignition system Same car as for Fig 1

Figure 2 shows the characteristics of this particular car when the ignition was on and the engine started The initial starting current was approximately the same as in figure 1 The engine started on the second compression At the point marked *A* the current was zero and the voltage at *A′* was approximately open circuit value. This is believed to represent the operation of the reverse current relay. An instant later the battery began to charge at a high rate—as indicated by the current curve falling below the indices and the voltage curve rising abruptly to a value in excess of the open circuit voltage. At *B* the starter pedal was released and the current returned to the normal charging value A corresponding drop in voltage occurred at the same time. The engine was racing at *C*, slowed down at *D*, and the ignition was cut off at *E*. The interruptions seen in the charging current are due to the current flowing through the ignition coil which is operated by the distributor.

Analysis of the curves has suggested the possibility of using this method for the study of problems relating to the design of engines and starter systems The method provides an exact means of measuring the speed of rotation and of detecting small changes in speed from one revolution to another. Additional experiments to show the effect of temperature compression, lubrication and throttle opening were made also. These will be described in the complete paper

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue

BOTANY.—*The influence of cold in stimulating the growth of plants.* F. V. Coville. Journ Agr Res **20**: 151 160. Pls. 20–35. 1920

The dormancy of trees and shrubs begins before the advent of cold weather. Cold weather is not necessary to bring about dormancy. It is necessary to bring about renewed growth in the spring. If not subjected to cold, dormant plants will not start growth in the spring. Even on the same plant a branch which has been chilled will start growth under proper conditions while an adjoining branch which has not been subjected to chilling will remain dormant. The best temperature for chilling is 32° to 40° F. It may be applied in either light or darkness.

During chilling the reserve food stored in the form of starch is changed to sugar Until this change has taken place the plant is unable to use the stored food for renewed growth. H V Harlan.

BOTANY.—*Revisions of North American grasses* A. S Hitchcock and Agnes Chase Contr U. S. Nat Herb. **22**: 1–77 Pls. 1–24, figs. 1–20 1920.

This number of the Contributions consists of four independent papers (1) The North American species of Ichnanthus, by Hitchcock, (2) The North American Species of Lasiacis, by Hitchcock, (3) The North American Species of Brachiaria, by Chase, (4) The North American Species of Cenchrus, by Chase *Ichnanthus* is a tropical genus allied to *Panicum* *Lasiacis* is a tropical genus of woody grasses, also allied to *Panicum*, one species of which extends into southern Florida. Of the 6 American species of *Brachiaria* two extend into Texas. The species of *Cenchrus* are usually known as sandburs. Eight of the 13 species described are found in the United States. A. S H.

BOTANY.—*Revisions of North American grasses* A. S. Hitchcock. Contr. U. S. Nat. Herb. **22**: 115–208 Pls. 25–32, figs 21–62. 1920.

This number of the Contributions includes four independent papers on the North American species of the genera *Isachne*, *Oplismenus*, *Echinochloa*, and *Chaetochloa*. *Isachne* and *Oplismenus* are tropical genera, one species of the latter extending into our southern states. The species of *Echinochloa* are widely distributed, some of them being common weeds One of the forms of *E. crusgalli*, barnyard grass, is cultivated under the name of Japanese barnyard millet. The species of *Chaetochloa* (*Setaria*) are also widely distributed. Some species are common weeds, such as *C. lutescens*, yellow foxtail, and *C. viridis*, green foxtail. One species, *C. italica*, is the commonly cultivated millet, or foxtail millet, one form of which is called Hungarian grass. One species is grown in greenhouses as an ornamental, the broad plaited blades giving it the name of palm grass. Twenty-six species are described and figured. A. S. H.

BOTANY.—*Heritable characters of maize. I. Lineate leaves.* G. N. COLLINS and J. H. KEMPTON. Journ Heredity **11**: 3–6. January, 1920.

This paper is the first of a series in which it is planned to record variations in maize that prove to be inherited. "Lineate leaves," the character here described, consist of a very fine, white striping of the upper leaf blades. The progenies of self-pollinated lineate plants and crosses between lineate and normal plants indicate that the character is a Mendelian monohybrid. The character is variable in expression, however, and 2 progenies out of 14 showed significant departures from monohybrid ratios. G. N. C.

ENTOMOLOGY.—*A revision of the nearctic termites.* NATHAN BANKS, with *Notes on biology and geographic distribution.* THOMAS E. SNYDER. U. S. Nat. Mus. Bull. **108**. Pp. 228, pls. 35, figs. 70. 1920.

This paper is divided into two distinct parts. The first deals with the taxonomy of the termites, or white ants, of the Nearctic Region, while the second part contains a comprehensive summary, supplemented by original observations accumulated by the junior author, of the habits and distribution of these interesting economic insects. In the part dealing with the taxonomy each species and genus is characterized in detail and synoptic keys to all the forms are given. Seventeen new species and one new variety are described, thus almost doubling the number of forms previously known. That portion of the bulletin which deals with the biology gives first a summary of the habits of these insects and discusses the nesting, feeding, swarming, mating, metamorphosis, castes, parasites, economic importance, control, etc., and then gives a complete account of the available information concerning each species.

This paper is the most important work on our white ants and no worker interested in these insects can be without it. S. A. ROHWER.

ENTOMOLOGY.—*Black grain-stem sawfly of Europe in the United States.* A. B. GAHAN. U. S. Dept. Agr. Bull. **834**. Pp. 18, pls. 2. 1920.

The black grain-stem sawfly (*Trachelus tabidus* (Fabr.)), a European pest of wheat, rye and similar grains, has been known to occur in the United States since 1899, but only in the last few years has it attracted attention as a pest. This bulletin gives a history of the discovery of the insect in America, what is known of its distribution, habits, host-plants, synonymy, injury, suggestions for control, parasites and a practically complete list of available literature. The adult is figured in both sexes and distinguishing characters for the larva, separating it from allied species living in similar situations, are included. This pest mines the stems of grains and besides thus reducing the ability of the grain to head does its greatest damage by cutting the stems close to the ground prior to the time it goes into hibernation. The cutting of the stems causes the grain to fall and thus escape the harvester. S. A. ROHWER.

ETHNOLOGY.—*Native cemeteries and forms of burial east of the Mississippi.* DAVID I. BUSHNELL, JR. Bur. Amer. Ethnol. Bull. **71**. Pp. 160, pls. 17, figs. 17. 1920.

The reports of early writers contain a great body of information regarding the burial rites and customs of our American Indians which are of particular importance to the archeologist, and in the present work Mr. Bushnell has brought together as much of the available material as possible applying to

the United States east of the Mississippi River. This is arranged under the headings of the several Indian stocks and an attempt has been made to co-relate it with the results of modern explorations. J. R. SWANTON

ETHNOLOGY.—*Alsea texts and myths.* LEO J. FRACHTENBERG. Bur. Amer. Ethnol. Bull. **67.** Pp. 304. 1920.

Alsea is a dialect of the Yakonan linguistic family, which formerly occupied a small portion of the Oregon coast southward of the Columbia River. So few Indians are now acquainted with it that the material contained in this volume is, in all probability, practically all that will ever be available for study. It consists of 24 native texts with English translations, five originally recorded by Dr. Livingston Farrand, now Director of the American Red Cross, and the remainder by Dr. Leo J. Frachtenberg, who also revised and edited the material collected by his predecessor. Four tales collected by Dr. Farrand in English, without native equivalents, are added, and the whole is followed by vocabularies in Alsea-English and English-Alsea and a list of formative elements. A brief introduction explains the various ways in which this series of texts was brought together and indicates the character of Alsea mythology and its position with reference to the mythologies of the neighboring peoples. J. R. SWANTON.

EVOLUTION.—*Kinetics of material transformations.* ALFRED J. LOTKA. Proc. Amer. Acad. Arts and Sciences **55:** 137–153. 1920.

A discussion along very general lines of the differential equations relating to systems undergoing change of state, chemical, physical, or other. The method and conclusions cannot be readily set forth in a brief abstract. While the immediate application is chiefly in the field of physical chemistry, a very general mode of treatment has been adopted with a view to preparing the ground for the discussion of the broad problem of evolution. A. J. L.

EVOLUTION.—*Evolution and irreversibility.* ALFRED J. LOTKA. Science Progress **14:** 406–417. Figs. 5. 1920.

It has been pointed out by biologists that organic evolution is an irreversible process. Physicists also have spoken of the second law of thermodynamics broadly as the law of evolution. In organic systems irreversible processes are attended with a decrease in certain functions of the variables defining the state of the system. Stable equilibrium is characterized by the fact that these functions assume a minimum value.

In the case of organic systems in the process of evolution we have not, in general, such definite criteria for equilibrium, and the direction of the process, although undoubtedly perfectly definite, has hitherto never been formulated in precise terms. The paper here abstracted sets forth, for certain cases at any rate, a precise formulation of the direction of evolution and a criterion for the stability of equilibrium in the familiar form of a function which assumes a minimum value at the point of equilibrium.

A. J. L.

GEOLOGY.—*Iron-depositing bacteria and their geologic relations.* E. C. HARDER. U. S. Geol. Survey Prof. Paper **113.** Pp. 89, figs. 37. 1919.

Iron-depositing bacteria are abundant and widespread in soil and natural water. They occur not only in surface waters but have been found in underground waters, such as well waters and iron-bearing mine waters, to depths

of more than 300 feet. They also inhabit distributing pipes and intakes of city water systems where the water contains an appreciable percentage of iron, and at times they become obnoxious in such situations

The best-known iron-depositing bacteria such as Crenothrix, Leptothrix, and Spirophyllum belong to the group of organisms known as thread bacteria. Many coccus and bacillus forms also are known, which have the power of precipitating ferric hydroxide or basic ferric salts from iron-bearing solutions. Some iron-depositing bacteria require iron compounds in solution for their life processes, others do not require iron compounds, but use them when present Some require inorganic iron compounds, others organic iron compounds, and still others use both Many of these organisms have been cultivated on artificial media

The importance of iron-depositing bacteria in the formation of iron-ore deposits is problematical They are known to form bog-ore deposits and have been found depositing limonite in openings at moderate depths Most of the large sedimentary iron-ore beds, however, are known to have been deposited in salt or blackish water and iron-depositing bacteria have not been found up to the present in such situations. E C H

GEOLOGY —*The copper deposits of Ray and Miami, Arizona* F. L. RANSOME U S Geol. Survey Prof Paper **115**. Pp 192, pls 54, figs. 29. 1919

The Ray and Miami districts lie about 18 miles apart in central Arizona, in the belt of mountain ranges that borders the Arizona Pla eau along its southwestern edge From the beginning of modern operations in 1907 to the end of 1918 these districts have yielded 1,098,409,607 pounds of copper and the three principal copper companies have declared dividends amounting to $67,592,552

The rocks of the region comprise pre-Cambrian schist and granite overlain by Paleozoic sedimentary rocks and limestones which in turn are unconformably overlain by Cretaceous andesitic rocks. Above these in the stratigraphic column are lavas and fluviatile detrital deposits of Tertiary and Quaternary age The principal intrusive rocks are diabase, probably of early Mesozic age, and granite, granodiorite, quartz diorite, and related porphyries, probably of early or middle Tertiary age

The principal copper deposits are of the enriched disseminated type and their most valuable constituent is chalcocite The tenor of the ore ranges from about 1 5 to 6 per cent and about 260,000,000 tons were estimated as available at the beginning of the present mining operations The ore bodies are undulating, flat-lying masses of more or less indefinite horizontal outline and of varying thickness In a very general way they are marginally situated with reference to intrusive masses of granite, granite porphyry, and quartz monzonite porphyry, but the ore occurs both in the pre-Cambrian schist and in the Tertiary intrusive rocks. By far the greater part of the ore is in schist The ore bodies are the result of the operation of two general processes—upward or hypogene metallization as a consequence of the intrusion of granite or monzonite porphyries, and downward or supergene enrichment by percolating atmospheric water.

Supergene enrichment has generally been treated as a continuously progressive process. There is considerable probability, however, that it is essentially cyclic, although the cyclic character may not be patent in all deposits. The essential fact appears to be that as enrichment progresses

and chalcocite increases, the process of enrichment becomes slower in action, and erosion may, in some circumstances, overtake it. With the removal of some of the protecting zone of chalcocite the protore, or original pyritic material, is again exposed to oxidation and a second cycle of enrichment begins. F. L. R.

GEOLOGY.—*Bibliography and index of the publications of the U. S. Geological Survey relating to ground water.* OSCAR E. MEINZER. U. S. Geol. Survey Water-Supply Paper **427**. Pp. 169, map 1. 1918.

Gives a brief historical statement of the work done by the Survey on the subject of ground water and lists 609 papers (in 454 volumes) which contain information on ground water, of which 307 papers (in 171 volumes) relate primarily to this subject. It includes brief abstracts of these papers and a detailed index with respect to ground water topics, and contains a map of the United States showing areas covered by the papers listed. O. E. M.

GEOLOGY.—*The Sunset-Midway Oil Field, California. Part I. Geology and Oil Resources.* R. W. PACK. U. S. Geol. Survey Prof. Paper **116**. Pp. 179, pls. 45, figs. 15. 1920.

The Sunset-Midway oil field lies at the south end of San Joaquin Valley, in Kern County, California. Deposits of asphalt and seeps of oil in this region were known to the earliest settlers, but real development did not begin until 1900. Up to the end of June, 1917, more than 2200 wells had been drilled in the field, and on that date 1840 were producing. Up to 1918 the field had produced more than 2,827,000,000 barrels of oil. The largest well flowed for 18 months, and is said to have produced more than 8,000,000 barrels of oil, with a maximum daily production of 65,000 barrels.

Granitoid and metamorphic rocks form the foundation upon which rest Tertiary and possibly some Cretaceous sediments. Structure is complex; in the mountain regions the rocks are much folded and faulted, but in the outermost foothills along the border of San Joaquin Valley the folds are broad and open and extend from the main range into the valley. It is about these obliquely trending folds that the petroleum has accumulated. The petroleum is thought to have originated in a Miocene diatomaceous shale, and has for the most part migrated and accumulated in the late Tertiary sandy beds that unconformably overlie the shale. Barren beds are found interspersed among the oil-bearing sands. Near the outcrop the oil becomes viscous or tarry and seals the beds more or less completely. In parts of the field where the oil is buried more than 2000 feet a zone of tar-filled sand lies less than 1000 feet below the surface. This zone is believed to mark the place where the upward-moving hydrocarbons have met and been oxidized by surface waters.

The paper includes descriptions of the individual areas with suggestions for future work. J. D. SEARS.

GEOLOGY.—*Geology and water resources of the Gila and San Carlos Valleys in the San Carlos Indian Reservation, Arizona.* A. T. SCHWENNESEN. U. S. Geol. Survey Water-Supply Paper **450-A**. Pp. 27 (1–27), pls. 4, figs. 2. 1919.

Most of the arable land in the valleys of Gila and San Carlos rivers, within the San Carlos Indian Reservation, Arizona, is undeveloped because of the inadequate supply of water for irrigation. The report deals with the physiog-

raphy, geology and water resources of the area, with special reference to the feasibility of drilling for an irrigation water supply in land not included within the proposed San Carlos reservoir. The Reservation includes a plateau area in the northern and eastern parts, and a basin area along Gila and San Carlos rivers. Igneous and pre-Quaternary sedimentary rocks were noted in the mountain areas, and the Quaternary Gila conglomerate in lake beds and river alluvium in the basins.

In 1914, with inadequate dams, the cost of irrigation was $1.34 an acre. Permanent dams are not recommended. The cost of pumped well water would probably be higher, but would be compensated by increased crops. The shallow-well water in the Gila valley is so highly mineralized that it is of doubtful value for irrigation, that in the San Carlos valley is though better but practical experiments should be made. Several structures favorable for artesian supply are described, and a test well is recommended.

J. D. SEARS.

NAVIGATION.—*The prospective utilization of vessel-to-shore radio-compass bearings in aerial and transoceanic navigation.* G. W. LITTLEHALES. Journ. Amer. Soc. Naval Engineers **32**: 38–44. Pl. 1. February, 1920.

A method of finding the latitude and longitude in aerial and marine navigation from vessel-to-station radio-compass bearings is described, and its mathematical theory is expounded. A plate of the construction employed in the practice of the method is given, together with illustrative applications.

G. W. L.

ORNITHOLOGY.—*The birds of North and Middle America.* ROBERT RIDGWAY. U. S. Nat. Mus. Bull. **50**, part 8. Pp. xvi, 852, pls. 34. 1919.

The eighth part of "*The Birds of North and Middle America*" is a systematic treatment of the Charadriiformes, with descriptions and synonymy of genera and species as in the previous portions of this work. The present volume contains the following families, all of which are referred to the order Charadriiformes under three suborders: (1) Limicolae with families Jacanidae, Oedicnemidae, Haematopodidae, Arenariidae, Aphrizidae, Charadriidae, Scolopacidae, Phalaropodidae, and Recurvirostridae, (2) Lari with families Rynchopidae, Sternidae, Laridae, and Stercorariidae, and (3) Alcae with the single family Alcidae. Of these families, the Arenariidae and Sternidae are here elevated from subfamily rank on what are considered sufficient anatomical characters.

Seven genera are here revived in the groups treated: three, *Endomychura* Oberholser, *Ciceronia* Reichenbach, and *Alcella* Stone, are raised from subgeneric rank; and the four others, *Blasipus* Bruch, *Chroicocephalus* Eyton, *Hydrocoloeus* Kaup, and *Mesoscolopax* Sharpe, are wholly additional. One new genus, *Neoglottis*, is instituted, with *Scolopax melanoleuca* Gmelin as type. Four generic groups recognized by some modern authors are considered not separable: *Onychoprion* Wagler, *Melanosterna* Blyth, *Limnocinclus* Gould, and *Leucopolius* Bonaparte.

In this volume 187 species and subspecies are treated. The guillemot known as *Cepphus motzfeldi* (Benicken), often commonly supposed to be an individual variation, is here given full specific rank, and the same treatment is accorded *Uria ringvia* Brünnich. The peculiar sandpiper *Pisobia cooperi* (Baird) is here treated as a good species. The recent Alaskan record of

Pisobia ruficollis (Pallas) is considered valid, and sufficient to warrant the inclusion of the species in the North American list. The Frazar oyster-catcher, *Haematopus frazari*, proves to be a subspecies of *Haematopus palliatus*, not, as commonly supposed, a full species. Nearly all the recently separated North and Middle American subspecies of shore-birds are suppressed as insufficiently distinct for recognition. Three new subspecies are herein described *Pagolla wilsonia beldingi* from La Paz, Lower California, *Pagolla wilsonia cinnamomina* from Sabanilla, Columbia; and *Sterna anaetheta nelsoni* from Sihuatnejo, Guerrero, Mexico. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Description of a whippoorwill from Porto Rico.* ALEXANDER WETMORE Proc. Biol Soc Wash. **32**: 235-238. December 31, 1919.

A whippoorwill from the island of Porto Rico appears to belong to a new species, and is here named *Setochalcis noctitherus*. It is most closely allied to *Setochalcis vocifera vocifera*, but differs in its shorter wing and certain color characters of the female. Bones of this species have been found in cave deposits on the island of Porto Rico and the species is now probably extinct HARRY C OBERHOLSER

ORNITHOLOGY —*Description of a new subspecies of Pipilo fuscus.* HARRY C. OBERHOLSER Condor **21**: 210-211. September 30, 1919.

A series of Towhees from the middle portion of the peninsula of Lower California belongs to an undescribed subspecies which may bear the name *Pipilo fuscus aripolius* Though occupying a geographic position intermediate between *Pipilo fuscus senicula* of northern Lower California and *Pipilo fuscus albigulus* of the Cape San Lucas region, this new race differs from the latter in its longer tail, and in its darker and more grayish coloration It is of considerable interest since it establishes direct and complete intergradation between *Pipilo fuscus senicula* and *Pipilo fuscus albigulus*, and shows that these birds are but subspecifically related This fact makes necessary the reduction of *Pipilo crissalis* and its races to subspecies of *Pipilo fuscus* H. C O

ORNITHOLOGY *The bird rookeries of the Tortugas* PAUL BARTSCH. Smithsonian Report for **1917**: 469–500 Pls 1–38 1919.

The small group of keys that compose the Tortugas is situated some 65 miles west of Key West, Florida These keys are of much ornithological interest since they furnish a breeding place for large numbers of water birds, particularly terns A census of the birds on these islands taken July 19-31, 1917, shows 32,810 individuals of 19 species present, although only *Sterna fuscata*, *Anous stolidus stolidus*, *Sternula antillarum antillarum*, and *Sterna dougalli* breed here. A list of all the birds hitherto found on the islands totals 129 While no land birds nest here this list is of interest as showing that the Tortugas are a good pausing place for north and south bound migrants The 38 half-tone plates represent chiefly various water birds, their nests, eggs, and young HARRY C OBERHOLSER

ORNITHOLOGY.—*Birds observed on the Florida Keys and the southern end of the mainland of Florida in 1919.* PAUL BARTSCH. Year Book of the Carnegie Institution **18**: 205–210. 1920.

Daily notes on the birds of the Florida Keys and southern Florida are

here presented in chronological order from December 28, 1918, to May 19, 1919 These observations furnish many data on the occurrence of birds in these localities. In all, 97 species and subspecies were observed, of which a list is given and on which notes are recorded. Of particular interest is an immature great white heron taken from a nest on one of the keys and subsequently sent by parcel post to the Zoological Garden at Washington; and a new subspecies of clapper rail from the sixth key southwest of Big Pine Key, to be subsequently described

HARRY C OBERHOLSER.

ORNITHOLOGY.—*The systematic position of the ring-necked duck* N HOLLISTER. Auk **36**: 460–463 1919.

A study of the ring-necked duck (*Marila collaris*) in life and in the laboratory indicates that this species is more closely related to *Nyroca americana* than to members of the genus *Marila* with which it is usually associated. It is the New World representative of *Marila fuligula*, and in a sequence of species or in the separation of allied species into generic or subgeneric groups, it should be placed between *Nyroca americana* and *Marila fuligula*

HARRY C OBERHOLSER.

ORNITHOLOGY.—*Federal protection of migratory birds* GEORGE A. LAWYER. U S Dept Agric. Year Book **1918**: 303–316 1919

Game birds, particularly waterfowl, have greatly decreased in the United States during recent decades. This condition has induced the various states of the Union to pass numerous laws for the protection of such birds. This has, however, not been sufficient, and a Federal law was enacted in 1913, while in 1916 the Migratory Bird Treaty between the United States and Canada was negotiated This treaty protects ducks, shore birds, insectivorous birds, and many other migratory species An enabling act validating this treaty was passed by the Congress of the United States in 1918, by which statute the Secretary of the United States Department of Agriculture is given jurisdiction over the administration of this law, and in him is vested the authority to promulgate regulations for its enforcement Many states have already conformed their laws to the Federal regulations, and the outlook for the increase of birds under such cooperation is bright.

HARRY C OBERHOLSER

ORNITHOLOGY.—*Habits and economic relations of the guano birds of Peru.* ROBERT E. COKER. Proc U S Nat Mus **56**: 449–511. Pls. 53–69. 1919

During the course of investigations on the guano and fishery industries of Peru many opportunities for observing the birds of the guano islands along the coast of that country were offered. The various sea birds of these rocky, barren islands produce annually 20,000 tons of guano, while between 1851 and 1872, 10,000,000 tons were extracted from the Chincha Islands alone. These islands, valuable as they are from a commercial standpoint, are not less interesting scientifically. The most important guano-producing bird of this region is *Phalacrocorax bougainvillei*, not, as commonly supposed, *Sula variegata*, which is much less valuable in this way than either the cormorant or the pelican. Of this species of cormorant there were estimated to be about 150,000 individuals on the Ballestas Islands,

and about 750,000 on the Chincha Islands, 400,000 of the latter being young. The next important producer of guano is *Pelicanus thagus*, of which 100,000 were found on the islands of Lobos de Afuera. Other birds are much less productive of guano, but make, however, some contribution. Among these other birds, those most conspicuous in this region are *Spheniscus humboldti*, *Larus dominicanus*, *Larus belcheri*, *Larus modestus*, *Sterna hirundinacea*, *Larosterna inca*, *Diomedea irrorata*, *Oceanites oceanicus*, *Hydrobates pelagicus*, *Puffinus griseus*, *Pelecanoides garnoti*, *Sula nebouxii*, *Phalacrocorax vigua*, and *Phalacrocorax gaimardi*. The 17 plates show various features of the remarkable avian fauna of these islands HARRY C. OBERHOLSER.

ORNITHOLOGY —*Notes on the races of* Quiscalus quiscula (*Linnaeus*). HARRY C. OBERHOLSER. Auk **36**: 549–555. 1919.

Recent investigations show that the three current subspecies of *Quiscalus quiscula* (Linnaeus) are fully entitled to recognition; but since *Quiscalus quiscula quiscula* (Linnaeus) was originally based on the bird from South Carolina, which is the same as the Florida race *Quiscalus quiscula aglaeus* Baird, it becomes the name for the southern race. The northern bird hitherto called *Quiscalus quiscula quiscula* proves to be without a name, since all the synonyms of the species relate to the typical form from the southern United States The birds from the middle and eastern United States are therefore named *Quiscalus quiscula ridgwayi*. H. C. O.

ORNITHOLOGY.—*Description of another new subspecies of* Lanius ludovicianus. HARRY C. OBERHOLSER. Wilson Bull. **31**: 87–90. 1919.

The breeding form of *Lanius ludovicianus* that occupies north central Lower California is a readily recognizable subspecies, and is here named *Lanius ludovicianus grinnelli*. It is a very darkly colored bird with little white on the scapulars, and small terminal white areas on the outer rectrices, and is apparently most nearly related to *Lanius ludovicianus anthonyi* and to *Lanius ludovicianus mearnsi*. Present investigations show that *Lanius ludovicianus mearnsi* is readily recognizable as a subspecies although commonly considered a synonym of *Lanius ludovicianus anthonyi*

H. C. O.

ORNITHOLOGY —*The status of* Larus hyperboreus barrovianus *Ridgway*. HARRY C. OBERHOLSER. Proc. Biol. Soc. Wash. **32**: 173–176. 1919.

A further investigation into the claims of *Larus hyperboreus barrovianus* Ridgway to recognition as a subspecies indicates that it is a tenable race It is distinguishable from *Larus hyperboreus hyperboreus* in the smaller size; in the relatively as well as actually slenderer bill, and in the noticeably darker upper surface H. C. O.

ORNITHOLOGY.—*Reports on the scientific results of the expedition to the tropical Pacific in charge of Alexander Agassiz. XXI. The birds.* CHARLES HASKINS TOWNSEND and ALEXANDER WETMORE. Bull. Mus Comp Zool. **63**: 151–225. 1919.

This is a report on collections made by Mr. Charles H Townsend during the cruise of the U S Fisheries Steamer "Albatross," in the Pacific Ocean from August, 1899, to March, 1900. During this voyage, which was undertaken for the purpose of studying the coral reef district of the tropical Pacific the following island groups were visited: Marquesas, Paumotu, Society,

Cook, Tonga, Fiji, Ellice, Gilbert, Marshall, Caroline, and Ladrone. There was made a collection comprising 406 specimens of birds, representing 93 forms, 14 of them here described for the first time. An annotated list of the species obtained gives various data on plumage, relationships, and distribution, and includes also various critical notes The new species and subspecies here described are as follows *Ixobrychus sinensis moorei*, from Uala Island, Caroline Islands, *Globicera oceanica townsendi* from Ponapé Island, eastern Caroline Islands; *Sauropatis sacra rabulata* from Eua Island, Tonga Islands; *Sauropatis sacra celada* from Vavau Island, Tonga Islands *Myiagra townsendi* from Kambara Island, Fiji Islands, *Conopoderas atypha* from Fakarava Island, Paumotu Islands; *Conopoderas atypha rava* from Whitsunday Island, Paumotu Islands, *Conopoderas atypha crypta* from Makemo Island, Paumoto Islands, *Conopoderas atypha agassizi* from Apataki Island, Paumotu Islands; *Conopoderas atypha nesiarcha* from Rangiroa Island, Paumotu Islands, *Conopoderas atypha erema* from Makatea Island, Paumotu Islands, *Conopoderas percernis* from Eukuhiva Island, Marquesas Islands, *Pinarolestes nesiotes* from Kambara Island, Fiji Islands; and *Wyzomela rubrata* [sic] *dichromata* from Ponapé Island, eastern Caroline Islands.

H. C. OBERHOLSER.

ORNITHOLOGY.—*Notes on North American birds IX*. HARRY C. OBERHOLSER. Auk **36**: 556–559. 1919.

The proper name for the bird now known as *Phaethon americanus* is *Leptophaethon lepturus catesbyi*, since the American bird is only subspecifically separable from *Leptophaethon lepturus* The form of *Scaeophaethon rubricaudus* occurring accidentally in North America proves to belong to the subspecies *Scaeophaethon rubricaudus rothschildi* instead of to the typical race as hitherto supposed The forms of the genus *Casmerodius* (*Herodias*) are commonly considered as distinct species. They are, however, only subspecifically related, as their individual variation clearly shows. Birds from Australia, separated recently as *Herodias alba syrmatophora* Gould by Mr. G. M. Mathews, do not appear to differ sufficiently from *Casmerodiues albus timoriensis* to be maintained as a separate subspecies The forms of this beautiful heron should, therefore, stand as *Casmerodius albus albus*, *Casmerodius albus timoriensis*, and *Casmerodius albus egretta*. The specimen that forms the basis of the North American record of *Charadrius dubius* Scopoli proves to belong to the recently distinguished race *Charadirus dubius curonicus*. This being the case, it should stand as such on our North American list.

H. C. O.

ORNITHOLOGY.—*A new subspecies of Prunella modularis from the Pyrenees* FRANCIS HARPER. Proc Biol. Soc Wash. **32**: 243–244 1919.

Several specimens of *Prunella modularis* from the Pyrenees of France represent a new subspecies, which is here called *Prunella modularis mabbotti*. It differs from its nearest ally, *Prunella modularis modularis* in the much more grayish, less rufescent coloration of the back and wings. The type locality is a mountain about three kilometers south of Salliagouse, Department of Pyrenees-Orientales, France.

HARRY C. OBERHOLSER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

614TH MEETING

The 614th meeting of the Biological Society of Washington was held October 30, 1920, at 8 10 p m , in the lecture hall of the Cosmos Club Vice-president NED HOLLISTER presided, and 41 persons were present.

Brief notes were submitted as follows DR T S PALMER announced the meeting of the American Ornithological Union in the United States National Museum, November 9 11, with concurrent exhibits in the Library of Congress and National Museum Dr L O HOWARD stated that during the summer he witnessed a flight of grasshoppers in France Part of the army was detailed to fight them In the course of the operations they found the grasshoppers to be a very desirable article of diet

Regular program

AUSTIN H CLARK *On crinoids*

In the recent seas there are found 576 species, 142 genera, and 28 families of crinoids, 76 species, 22 genera, and 6 families include stalked forms, while 500 species, included in 120 genera and 22 families, are comatulids The speaker discussed the interrelationships of the crinoids, viviparous crinoids, sexual differentiation, regeneration, asymmetry, the composition of the crinoid skeleton, distribution, the paleontological history of the recent crinoids and their relation to the fossils, the occurrence of the littoral crinoids, the re ation of the crinoids to temperature, food, locomotion and color, and the extraordinary close structural correspondence between crinoids and plants, with the reasons for it He called attention to the fact that the fixed marine animals are most markedly differentiated by their food-collecting mechanism, while the plants are chiefly differentiated by their flowers, paralleli m in the conditions to be met has resulted in the polyps and the crinoid crowns and the insect-pollinated flowers adopting a similar form and differential value He also mentioned that the arrangement of the gonads in the crinoids is essentially similar to that of the flowers in wind pollinated plants The paper ended with a discussion of the plant-like relationships existing between the crinoids and the arborescent marine animals and their parasites (Author's abstract) The paper was discussed by Dr L O HOWARD and Mr A A DOOLITTLE

WALTER J SWINGLE *Chinese botany and Chinese botanists*

Mr. Swingle commented upon the exceeding richness of China's flora, especially that of trees and shrubs. China possesses all but one of the genera of woody plants occurring in the United States, besides many of her own The causes were traced to the absence of natural barriers to free north and south migration of species during the glacial periods The number of species in some of the genera, and the importance of many of the species to agriculture, were discussed Mr Swingle stated that China had a very ancient botanical literature. Some of the works of great magnitude and value date back for

more than ten centuries, and are more creditable than some recent works in occidental countries. There are still some very active botanists, one of whom has published the largest descriptive treatise ever attempted, and one of great merit. Successful agricultural schools are established, as well as re-foresting projects. The paper was illustrated by lantern slides of Chinese plants, plant environments, books, gardens and botanists. The paper was discussed by Mr. T. L. GARY.

615TH MEETING

The 615th meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club on November 13, 1920. Vice-president NED HOLLISTER called the meeting to order at 8.10 p.m., with 40 persons present.

On recommendation of the Council Messrs OSCAR P. SILLIMAN, Salinas, California, M. SLOOG, of the A. L. P. Agence de Libraire de Publications, New York City, S. STILLMAN BERRY, Redlands, California, and HERBERT J. PACK, Logan, Utah, were elected to membership

Informal communications

Dr PAUL BARTSCH stated that the ship-worm problem in San Francisco Bay is reaching important proportions. The Navy has lost $7,000,000 worth of piling, and commercial shipping has sustained a loss of $5,000,000 The damage is caused by a *Teredo*, probably undescribed. Dr. Bartsch also referred to two land shells, Epiphragmophora, which have probably been differentiated very recently One, a large form, was rather rare under the needles of cypress, and at a little distance, occurring only on rocks under shelter, *Mosambrianthum*, a composite, was a smaller form, otherwise identical. Each had its own associates. Also in the Hawaiian Islands, Dr Bartsch noted a honey-eating bird with the same repulsive odor as that of the Honey Creeper of South America. An explanation of the similarity of odors was desired.

Dr. T S. PALMER, referring to the meeting of the American Ornithological Union, recently held in Washington, said that the attendance was 140, out of a membership of 1140, the largest on record. The attendance at the technical sessions indicated great interest The Chairman remarked, apropos of interest in the more technical aspects of biology, that the symposium upon subspecific characters brought out both large attendance and great interest, when the subject was wholly technical.

Mr. WILLIAM PALMER exhibited the type skull of *Rhabdosteus*, one of several genera of very peculiar dolphin-like animals, possessing extremely extended upper jaws. Mr Palmer exhibited parts of a similar skull, enough to reconstruct a skull 39 inches long, collected from the beds south of Chesapeake Beach, Maryland

Regular program

R W. SHUFELDT: *A snake affected with chiggers.*

A black snake was found by Dr. Shufeldt which had unusual swellings in the skin of the anterior third of the body. The animal could not shed the skin thus affected, and seemed to be considerably discomfited. A little soaking in warm water enabled the skin to be removed easily, and the snake gave evidence of relief. The snake had been in the hands of several biologists, and on coming into the hands of Dr. H. E. EWING, of the Bureau of Entomology, the skin was microscopically examined, and was clearly found

to be harboring a number of chiggers. The pests were confined to the scaly outer membrane. A photograph of the infected snake and microscopic preparations of the skin showing the chiggers were exhibited.

Dr. Shufeldt's paper was discussed by Dr. BARTSCH, who had seen ticks upon a black snake. Mr WM. PALMER had noticed ticks on the Pine Lizard. Mr. GOLDMAN had found ticks common in the ears of snakes and lizards in South America. Dr. EWING, commenting upon the specimen and in answer to questions raised, said that the chiggers were doubtless wholly adventitious upon the snake, and that the instance did not throw any light upon the life history of the chigger, which was unknown, except in the case of a disease-bearing species of Japan. The supposed immunity of individuals to chiggers, their very unequal distribution, even in circumscribed areas, and other problems connected with their life history and economic relations, were discussed. Col. THOMAS CAREY emphasized the need for investigations of this pest.

CHARLES W. GILMORE: *Remarks on some additions to the fossil vertebrate exhibition in the National Museum.*

Dr. Gilmore discussed some of the difficulties involved in building up a representative exhibition collection of fossil vertebrates. It was pointed out that of 20,000 specimens in the National Museum, only 40 were articulated skeletons, or of every 1000 specimens collected, only two might be expected to be perfect enough to be suitable for exhibition purposes. This ratio was not considered a constant one for all collections, but it indicated the comparative rarity of well-preserved fossil vertebrate specimens.

It was shown that the articulation and mounting of fossil skeletons for public exhibition is a comparatively recent phase in the development of vertebrate paleontology in this country. Very few were thus exhibited prior to 1900, and the first skeleton in the National Museum was set up in 1902.

The great amount of time consumed in prepairng fossil skeletons for exhibition was discussed. A skeleton of *Dimetrodon* required 533 working days, and that of *Stegosaurus* 626 days, or more than two years' steady work for one man. The style of mounts was briefly touched upon, and the desirability of preserving articulated skeletons, especially of the reptiles, in the positions in which they were found in the field, was emphasized.

The National Museum was said to rank third on the list among American museums having similar exhibits of extinct vertebrate life.

Following this brief discussion Dr. Gilmore exhibited slides of the more important accessions to the collection in recent years. The most striking of these were: *Stegosaurus*, an armored dinosaur; *Ceratosaurus*, a flesh-eating dinosaur; *Dimetrodon*, a giant spined reptile; *Brontotherium*, a large mammal from Nebraska, *Epigaellus*, a horned rodent from Kansas; *Stenomylus*, a small camel from Nebraska. The more striking characteristics of these animals were pointed out and life restorations were shown, including two modeled by the speaker and here exhibited for the first time. (Author's abstract.)

The paper was discussed by Drs. T. S. PALMER, SHUFELDT, and BARTSCH.

A. A. DOOLITTLE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The National Geographic Society announces the foundation of a series of Memoirs for the publication of the results of its expeditions. The first number will be devoted to a general account of the Katmai Expeditions, and technical papers on the botanical, entomological, geological and chemical results will follow. Prof. R. F. GRIGGS, director of the Katmai Expeditions, has been requested to devote his full time to the completion of this series of reports, and has accordingly resigned from the faculty of the Ohio State University and has taken up his residence in Washington.

At the request of the Radio Dynamic Torpedo Unit, Coast Artillery Corps, U. S. Army, arrangements have been made for the cooperation of the Coast and Geodetic Survey with the U. S. Army in the securing of data on currents in connection with the development of subaqueous sound ranging.

The Secretary of State has authorized Mr. WILLIAM BOWIE, who, prior to the war, was a member of the Permanent Commission of the International Geodetic Association, to notify the secretary of the Neutral Geodetic Association that the United States formally withdraws from this association. In 1916, a number of neutral countries—the United States being one of them—voted to continue the International Geodetic Association. When the United States entered the war it ceased to take an active part in this association.

Within the two years of its existence the new Czecho-Slovak Republic has established two new universities, one at Brno (Brunn) and the other at Bratislava (Pressburg). In addition the University at Prag finds itself this year with a nearly redoubled number of students, of whom there are now over 10,000. With the generally and greatly reduced exchange values of European currency, it has become exceedingly difficult for the scientific men of these universities to provide themselves with literature in all branches of learning published since 1914, and they appeal to their American colleagues for all possible help in this direction. Publications should be sent to Dr. A. HRDLICKA, U. S. National Museum.

The Division of Plants of the National Museum has received a package of plants from the State of Oaxaca, Mexico, collected by Professor C. CONZATTI, who has from time to time during the last twenty years forwarded to the Museum several thousand Mexican plants. Most notable among the specimens of this last shipment is a branch from the famous cypress tree at El Tule, near the city of Oaxaca. This tree, which is many centuries old, has a trunk circumference of over 100 feet and a height of about 130 feet, and is one of the largest trees known.

A valuable and well-mounted collection of moths and butterflies, including many from Oriental countries, collected by the late J. P. IDDINGS, petrologist and mineralogist, has been presented by his heirs to the National Museum.

Dr. GEORGE I. ADAMS, formerly with the U. S. Geological Survey, spent October in Washington. Since leaving the Survey he has been professor of geology in the Government University at Peking, China, and is now pro-

fessor of geology and mineralogy in the University of Alabama, at Tuscaloosa, Alabama.

Dr. H. FOSTER BAIN, consulting geologist and mining engineer, and formerly editor of the *Mining and Scientific Press* and the *Mining Magazine*, has been nominated as Director of the Bureau of Mines, Department of the Interior, to succeed Dr. F. G. COTTRELL, who resigned on January 1 in order to devote full time to his work as Chairman of the Division of Chemistry and Chemical Technology, National Research Council.

Dr. HENRY ANDREWS BUMSTEAD, professor of physics and director of the Sloane Physical Laboratory, Yale University, and chairman of the National Research Council in Washington, died on January 1, 1921, while on his way to Washington from the Chicago meeting of the American Association. Dr. Bumstead was born at Pekin, Illinois, March 12, 1870 He had been connected with the department of physics at Yale since his graduation from Johns Hopkins University in 1891. His research work had been chiefly in the fields of radioactivity and Röntgen radiation. During the war he was scientific attaché to the American Embassy in London.

Dr. M. E. HOLMES has been appointed manager of the chemical department of the National Lime Association, with offices at 918 G Street, Washington.

Mr. B. L. JOHNSON has been placed in charge of the Section of Foreign Mineral Reserves of the U. S. Geological Survey.

Mr. FREDERICK H. NEWELL, formerly Chief of the U. S. Reclamation Service, who in 1915 became professor of civil engineering at the University of Illinois, has withdrawn from his university work and is again making his headquarters in Washington.

The party under E. W. SHAW, including G. L. HARRINGTON, EDWIN KIRK, and C. P. ROSS, geologists, and R. H. SARGENT, topographer, which for nine months has been making geologic and topographic surveys in South America, has returned to this country. Mr. Shaw resumed his regular work on the Geological Survey in January.

Prof. C. J. TILDEN, professor of engineering mechanics at Yale University, has been granted leave of absence for a year to accept the position of director of the highway and highway transport education committee, of which Dr. P. P. CLAXTON, U S. Commissioner of Education, is chairman. The new director will take charge immediately of the work planned by the committee, which includes the compilation of economic, scientific, and engineering data relative to highway construction and highway transport, and the distribution of these data to educational institutions.

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GENERAL SCIENCE.—*The distribution of scientific information in the United States*[1] ROBERT B SOSMAN, Geophysical Laboratory, Carnegie Institution of Washington

Of making many books there is no end --ECCLESIASTES xii, 12
But easy writing's curst hard reading —SHERIDAN, *Clio's Protest*

My two texts represent only two facets of a many-sided subject, about which much has been written and on which many opinions have been held. In this brief address I can hope only to sketch an outline of the subject as it appears from the standpoint of the scientific investigator, and illustrate the sketch with a few data drawn from observation and experiment

For a subject so much more closely allied to applied sociology than to philosophy or "natural science," I cannot do better than make use of that excellent outline for any sociological discussion made familiar to the public by Professor Irving Fisher[2] Any sociological problem may be considered under the following four heads (I) What is it? (II) Why is it? (III) What of it? (IV) What are you going to do about it?

I THE PROBLEM OF DISTRIBUTION

It was much in fashion before 1914 to argue about the relative merits of different systems of *production* Most of our interest seemed to be directed toward the problem of producing commodities for human needs, and relatively little to the problem of distributing

[1] Address of the retiring president, Philosophical Society of Washington, presented at the meeting on January 15, 1921 Received January 22, 1921

[2] *American problems of reconstruction* (New York, 1919), p 362

those commodities when produced. It required the stress of war conditions in 1917 and 1918 to wake us up to the fact that production was far better organized than distribution. It was not the factories and mines and farms that had to be taken over and unified under government control to meet war emergencies, but the railroads, steamship lines, export organizations, and wholesale and retail agencies of *distribution*

An analogous situation has existed in the field of research for new knowledge. Private funds are expended in elaborate investigations; university laboratories and personnel are devoted to research on every conceivable subject, great foundations are established to carry forward systematized inquiry into problems too extensive for individuals to handle; and State and Federal governments devote large annual appropriations to obtaining new and useful knowledge through experiment and observation. Of what use is all this effort, unless its results be made available so that the public may benefit, intellectually or materially?

Yet the distribution of all this information is, relatively speaking, neglected, and left to the uncertain channels of the untutored private author, the unsympathetic clerk, or the sensation-seeking news agency Much of it practically disappears from view soon after its discovery

Let me emphasize this statement of the situation by a concrete example, taken from an informal communication by Mr R. W. Stone[3] before the Geological Society of Washington in November, 1917

About the year 1902 representatives of the Geological Survey of the State of Washington observed that the rock in a certain "marble" quarry consisted almost entirely of crystalline magnesium carbonate. Similar rocks were at the same time shown to exist at other localities in the State The chemical analyses and other facts were published by the State Survey. Meanwhile the "marble" proved to be not a success as a building or decorative stone and the original quarry was abandoned and grew up in weeds

Then came the World War, and by 1917 Austrian magnesite, which had until then been delivered on the Atlantic coast for the eastern steel works, was completely cut off. A massive magnesite from California then began to be shipped east Chemical analyses showing that a better magnesite existed in Washington slumbered

[3] This JOURNAL 8: 99 1918

on the shelves. Meanwhile there came into the story a wandering lumber-cruiser, who happened to pick up a piece of the "marble" in the weed-grown quarry, and showed it to an official of a pulp company, who gave it to his chemist. The chemist reported that it was nearly pure $MgCO_3$. The official promptly bought the quarry for a nominal sum, resigned from the pulp company, and in a few months was shipping several hundred tons of magnesite per day, at about forty dollars per ton, to Ohio and Pennsylvania steel companies

The *producers* of the original information did their task well, its *distributors* did theirs so poorly that the product never reached its ultimate *consumer*, the average citizen of the United States, in the crisis when he most needed it, and he had to fall back upon its rediscovery through the chance curiosity of a wandering lumberjack who had never read a geological bulletin in his life.

Probably every one of you could provide a similar story from your own experience to illustrate *the futility of publication* But why should anyone be so unaware of vital facts, in a land which is flowing with publications and in which nearly everyone can read? The consideration of this question brings us to our second heading

II THE CAUSES OF INEFFECTIVE DISTRIBUTION

In the case of that minority of the population which can not read, ignorance of the very existence of useful information is sufficient to account for its failure to be distributed This obvious cause needs no analysis

The case that requires looking into is the case of that large proportion of the population which can read, if it will. The present ineffective distribution of information to this part of the population may be traced to two causes. (1) *disinclination* to use the knowledge we possess, (2) *inaccessibility* of the information when it is desired

It is a familiar fact that the first reaction of the average individual to a new situation which contains elements of danger is to "hope for the best." This is true over the whole range of incidents from a "common cold" to those sources of international friction which result in wars. Scientific information—which means simply the systematized results of experiment and observation—is available as a guide to action in most of these situations, but we quite often proceed as if no human beings had ever had to grapple with such a problem before, or as if no record existed of the results of such

experiences One philosopher, experienced in research, administration, and politics, refers to this lamentable fact as "the law of the conservation of ignorance"[4] Perhaps this law is only a natural inheritance from our happy-go-lucky simian ancestors,[5] but I gladly leave that problem to the anthropologists, psychologists, and psychoanalysts, and turn to the second cause of ineffective distribution, one which comes much more within the ken of a physical scientist.

THE INACCESSIBILITY OF SCIENTIFIC INFORMATION

It might seem that in a land so full of newspapers, periodicals, books, reading rooms, libraries, museums, lecture halls, and "movie" theaters, one could not properly speak of the "inaccessibility" of published information But this very abundance is the first of three important causes that make any particular item of information quite inaccessible A second cause is found in the extremely heterogeneous character of the product And a third is the physical inability of some of our methods to connect producer and consumer, as will appear from a quantitative analysis of the situation

In looking into this matter in more detail, I wish first to separate our complicated modern methods of distributing information into their "pure components," in order to see in what respects each one fails, or is likely to fail, in effectiveness

But let it first be clearly understood that we are discussing the distribution of *information*, not *advice* To illustrate in the field of human physiology and pathology it is our custom seldom to ask the physician for information, but to expect only advice, that is, recommendations as to what to do next To be sure, advice is what we usually need, and its distribution will always be a more necessary and a much larger industry than the distribution of information, but it is too big a subject to receive more than this passing mention here

Under the term "scientific information" I shall include all systematized knowledge, gained by laboratory experiment, by observation of natural phenomena, or by the bringing together of old facts in new and significant combinations. Let us consider the channels by which this information is conveyed from its discoverer or assembler (the producer) to other individuals or to the public at large (the consumers). Five important channels may be distinguished:

[4] Carnegie Institution of Washington, Year Book 15: 14 1916.

[5] CLARENCE DAY, JR *This simian world* (New York, 1920)

(1) personal communication, (2) the public lecture, (3) the museum or exhibition, (4) the printed page, (5) the "movie" film.

We shall also bear in mind that for our present purposes a fairly sharp division can be drawn between two classes of consumers. The one, relatively small in numbers, consists of those who themselves are also producers of information, while the other consists of the greater part of the country's population

Distribution by personal communication - Undoubtedly the most effective method of distributing information, as far as the individual is concerned, is by personal communication Anyone who has tried it knows that to discuss an unfamiliar subject with a specialist in that subject for an hour or two is equivalent to reading about it for a week

Unfortunately, this method, the most effective of all as regards the individual, is the least effective of all as far as the public is concerned The actual producers of scientific information in the United States form a very small fraction of the population Those who devote all or part of their time to this pursuit can hardly number more than 50,000 If, then, every person in the country went to an original source only once a year for information, each producer would have to talk with 2120 inquirers per year, or about 7 persons per day on every one of 300 working days Needless to say, production of new information would practically cease under such circumstances.

This interference of distribution with production, which I have just hinted at, is more serious than we are accustomed to consider it, for though every inhabitant of the United States does not seek original information even once a year, there are many inhabitants who seek it much oftener than that Industrial concerns, with whom reliable new information is often a matter of success or failure, realize the value of personal contact and do not hesitate to send representatives on long journeys and pay their expenses for considerable periods, in order to get into personal touch with original sources. The public or quasi-public investigator also realizes it, sometimes to his sorrow. There is frequent complaint from members of the Government scientific bureaus that their time is seriously broken up by requests for information, in person, by telephone, or by letter. As one member of an active research organization expressed it, "I wish they would give me either the job of supplying information or the job of doing research; I cannot attempt both at once without spoiling them both."

The distribution of information to fellow-producers by this method, in exchange for similar information from their experience, is, however, one of the most important factors in the production of new knowledge, and is to be sharply distinguished from "unproductive" distribution to the public.

The informational middleman—We have seen that the public as a whole cannot have access to the original sources, either in person or by mail This kind of situation has been met in the commercial world since time immemorial through the aid of the middleman,—broker, commission merchant, wholesaler, retailer Most of these agencies perform a useful service, which must be paid for, as organizers of cooperative distribution frequently find to their cost. Although the distribution of information is not as elaborately organized, its agencies are quite analogous to those used in commerce Two types are to be distinguished, however first, those which distribute information freely or at a nominal fee; and, second, those which distribute it for profit

To the first class belong the information offices of the larger governmental bureaus, standing between the investigator and the public. A particularly effective example of this type is constituted by the "demonstration agents" of the Department of Agriculture and the State agricultural colleges In 1919, 1200 "county agents" in the northern and western states conducted over 90,000 demonstrations reaching 1 million people, besides distributing information personally to individuals in various other ways Other examples of the philanthropic type are the Research Information Service of the National Research Council, which aims to bring investigators into touch with each other, and the informational staffs of our public libraries

In the second class, those operated for profit, the agencies distributing commercial and financial information are much further advanced in organization than those concerned with the physical and natural sciences Babson's financial and investment service is a type in the field of economics The corresponding function for chemistry, physics, geology, and related sciences is usually still handled as a part of the work of the consulting engineer, although in certain establishments like that of Arthur D. Little, Inc., this part of the work is given an important position and dignified with offices and records of its own. It is also a growing custom for manufacturers to employ representatives in Washington to keep them in touch with the Federal bureaus.

In the field of human physiology and pathology, as before remarked, the sale of information is distinctly a minor matter compared with the sale of advice [6] This case serves very well to illustrate another restriction on the distribution of information for profit, namely, that the information is frequently a part of the working capital and equipment of the middleman (physician, consulting engineer, etc), and if sold should bring a much higher price than advice We should logically and reasonably expect to pay at least twenty times as much for the one as for the other

To summarize· The method of personal communication of information, direct or through the middleman, is effective enough as between producers; but is usually quite ineffective with respect to the public simply from physical inaccessibility, except in certain cases where it has been organized on a considerable scale for the definite purpose of distributing certain kinds of information

Distribution by public lectures —It is probable that men have always assembled together for the purpose of being harangued, exhorted, or entertained by one of their number, but their assembly to receive information from a speaker or reader seems a development of modern civilization Even now, there are relatively few human beings who can be induced to sit still for more than a few minutes to hear facts stated or theories expounded, even when it is done with skill and in an interesting way. Such folk are mostly to be found in scientific or cultural societies, yet even in this limited circle I have observed (at a general meeting of the American Association, for example) that there are often more members in the lobby than there are listening to the papers

All this is merely an expression, I suppose, of the fact that although the ear is a very much better physical instrument than the eye, impressions received through spoken words have only a fraction of the clearness of impressions received through the sense of sight

As before, we may distinguish between philanthropic lecturing and lecturing for profit The comparative rarity of the latter in its pure form is perhaps an indication of the method's essential ineffectiveness, to which reference has already been made. It is seldom if ever used commercially without the assistance of some oth r appeal, such as moving pictures or the attraction of getting a personal view of some celebrity.

[6] In this field we have the condition, anomalous in a community whose form of government is based upon the assumption of an intelligent and informed public, that the sale of certain kinds of information is forbidden by law

Philanthropic lecturing is done almost entirely through the medium of scientific or technical societies, which have now become very numerous. Washington alone possesses 35 or more.[7] The distribution of information by lecturers is also a secondary activity of many social organizations Finally there should be mentioned its use, admittedly rather ineffective, in college and university instruction. Altogether, assuming that there are annually in the District of Columbia 300 meetings of scientific societies, 500 lectures before social organizations, and 3000 lectures in our 8 universities and colleges, with an attendance of 50 persons at each, a public informational lecture reaches a given individual in the District on an average once in every 2 4 years And Washington is undoubtedly ahead of most American cities in this respect

To summarize The public lecture is largely used for the distribution of information among producers of information, in which function its effectiveness, though not small, is limited more by the heterogeneous character of the output than by any other factor It is very ineffective with respect to the public, not so much from physical inaccessibility as from the limitations set upon it by the laws of psychology

Museums and exhibitions —Next in logical order after methods of personal communication and public announcement should be placed methods depending on the exhibition for public study of objects, specimens, models, etc Although the temporary "exhibition" or "exposition" and the permanent museum both have a function as distributors of information, they can be traced to rather different origins, the exhibition, to the market or "fair," designed to bring together buyers and sellers of commodities, the museum, to the ecclesiastical or imperial collection of objects of art, trophies, and "curiosities," which collections later became the property of the public and were devoted to purposes of public instruction

The evolution of the modern scientific museum has been particularly rapid It has been hardly fifty years since the museum began to be looked upon as something more than a repository for the specimens collected by explorers and a place for the study and comparison of natural objects by specialists, and as offering tremendous possibilities for the diffusion of knowledge. As compared with its predecessors, the museum of today stresses the verb "diffuse" much more than "collect."

[7] *Directory of the Washington Academy of Sciences and its affiliated societies*, 1921 edition

There is a curious psychical limitation on the effectiveness of the museum, arising from the feeling on the part of many that a museum is a place where dusty and cob-webbed curios have lain on shelves for years, a place which one visits once in his lifetime, while "traveling." The population of the District of Columbia is a little over 0 4 million. During the twelve months ending with June 1920 practically this number of people visited the main building of the National Museum, and it is probable that the most of these were tourists or travelers Yet in the same period the National Zoological Park, containing much that is interesting but little that is usefully instructive, entertained over 2 2 million visitors

The arithmetical limitation on the effectiveness of a museum may be seen from the fact that if every city in the United States having 10,000 or more inhabitants possessed a museum, and if a given object in each were examined for two minutes by each one of a constant stream of visitors passing all through a 7-hour day every day in the year, then every person in the United States would have such an opportunity for instruction once every three years

The psychical disinclination to make real use of a museum is absent in the case of the "exhibition," "exposition" or "fair," which is available only for a short time and must be taken advantage of at once or not at all The commercial world has made use of this medium of distributing information to a much greater extent than the scientific world, but its possibilities are well illustrated on the small scale by the success of such expositions as that held a few years ago by the Washington Academy of Sciences, and by the exhibition of the wireless telephone held in Washington last year by the National Research Council and the American Telephone and Telegraph Company, and on the large scale by the National Exposition of Chemical Industries in New York, which instructed over 0.1 million people during its few days of activity last September.

To summarize: The museum and exhibition are more efficiently utilized by the public than by the investigator. It is probable that comparatively little new knowledge is distributed to its producers by this channel. The method is physically unable, however, to reach the whole public effectively; but it is, of all the means of distribution, the one most capable of neutralizing, by systematic and correlated exhibits, the disadvantage of heterogeneity.

Distribution by the printed page.—The changed circumstances of the world that followed from the invention of printing, and especially

from the invention of the chemical and mechanical processes for the manufacture of wood-pulp, need not be gone into here Social philosophers alternately approve and lament the change. It is plain that we are almost literally carried along on a stream of wood-pulp The country's activities are nearly as dependent on a constant supply of printing and writing paper as upon constant supplies of coal and iron About 3 4 million metric tons of printing and writing paper were manufactured in the United States in 1918, or 29 kg for each individual It will be of interest to inquire how much of this was used for the distribution of scientific information, and how effectively

Books —Of all the means of distribution by printing, that by books is intrinsically the most effective The term "book" is a little difficult to limit, but I include under the term any publication in which one subject or group of subjects is treated in a single unit, with some attempt at completeness or comprehensiveness. This would include, for example, some of the bulletins of the Federal and State geological surveys, but not all

Most scientific and technical books are published for profit The output in this class in the United States in 1920 I estimate at about 1900 works including new editions [8] If we assume that the average number of each printed was 1000, the total would be about equivalent to one volume to each 55 individuals of the population per year. Their effectiveness is not represented by this figure, however, because the use of each is considerably multiplied by the existence of public libraries, fairly exact quantitative data on this point might be obtained by the study of existing library statistics

A second group comprises books which are made to pay the cost of their paper, printing and binding. Examples are the publications of the West Virginia Geological Survey, the Carnegie Institution of Washington, and some Federal bulletins These are usually distributed free to libraries, and reach a much larger number through that medium than by direct sale.

A third group comprises books distributed free or at a purely nominal charge. This includes the greater part of the "book"-literature among the publications of the Federal bureaus and State experiment stations. These books likewise receive wide use through libraries, perhaps wider in certain cases than by direct free distribution

[8] See also F E. WOODWARD. *A graphic survey of book publication, 1890–1916* Bur Education Bull 1917, No 14

Contrary to what might logically be expected, the efficiency of distribution of books made and sold for profit appears to be greater than that of books distributed free or at cost The reason is perhaps that the life of the business, in the former case, is absolutely dependent on efficient advertising of the books produced The carrying of an adequate stock to meet the demand is also necessary On the other hand, institutions distributing books free or at cost do not always feel the necessity of advertising or of carrying stocks, or even of providing adequately for the prompt and business-like handling of requests As to their use in libraries, my few observations lead me to believe that books are valued and cared for by librarians, just as by individuals, approximately in proportion to what it has cost to obtain them

To summarize As a means for the distribution of information among its producers, books are relatively effective, those published for profit rather more so than those published at cost or distributed free For distribution to the public they are less effective, the disparity between profitable and philanthropic also being markedly greater, but they still probably exceed in present effectiveness any other form of printed matter With respect to both classes of consumers, scientific books are not so numerous but that the desired information is reasonably accessible, and they serve the invaluable purpose of sifting and sorting the new knowledge as it comes out of the mill But they are under the disadvantage of being from one to twenty years behind the times.

Scientific and technical periodicals and bulletins —It is difficult to visualize the tremendous volume of printed matter which is daily made available to the reading public The greater part of it consists of newspapers, general periodicals, and popular books, but even the small fraction of it which is devoted to science is impressive in its bulk The American Chemical Society, for example, printed about 250 metric tons of reading matter during the year 1920 It distributed to each of its members 15.0 kilograms of chemical information, contained in about 8400 printed pages exclusive of advertising.

I might tell you, in the customary manner of statisticians, how many times these pages could be made to girdle the earth, except that such comparisons are about as meaningless as the original figures, since nobody has any concrete picture of the size of the earth A much better realization is had of the bulk of this one year's chemistry if I point out how long it would take to read it aloud.

One can easily calculate that to read aloud at reasonable speed the publications of the American Chemical Society for 1920 would require about 514 hours, or 64 full working days of 8 hours each—over two months After seeing these facts it is not difficult to believe the statement that no one individual can be fully informed as to the progress of chemistry in all its branches

After thus getting a realizing sense of the overwhelming bulk of the Chemical Society's publications, let us recall that numerous other agencies also are publishing chemical information. Then add to this the volume of reading matter put forth by physicists, engineers, geologists, astronomers, and biological scientists of every variety, through the medium of publication agencies numbering in the scores for this country alone, and the "futility of publication" of which I gave an illustration at the beginning of this address becomes readily understandable

Like all the other media of distribution which we have considered, this type must be divided into two classes, the philanthropic and the profitable

In the philanthropic class belong the journals and proceedings of the scientific and technical societies, and the current bulletins of Federal and State bureaus, university laboratories, and museums. As a group the philanthropic periodicals are characterized by two features both of which are inimical to effective distribution. subdivision into a large number of independent units, and small circulation of each unit There were listed[9] in the United States in 1920 about 240 strictly scientific and technological publications, not including such as might be more properly called "trade journals," of which there were about as many more About 100 of those which I have classed as "scientific and technological" were medical periodicals Apparently about one-fourth of the remainder (those devoted to "science and engineering" as ordinarily understood) were published for profit The circulation of the philanthropic class varied from 75,000 for the *Journal of the American Medical Association* down to 175 for the *Journal of Entomology and Zoology* of Claremont, California, but the greater part of the scientific and technological group had a circulation of the order of magnitude of 500 to 800

The Federal bureaus in Wash ngton publish about 75 different series of publications of a scientific or technological character, not counting

[9] *Ayer's American newspaper annual and directory* (Philadelphia, 1921) Evidently the list is far from complete. Probably no list approaching completeness is in existence, although one is now in course of compilation at the Smithsonian Institution

maps and annual reports.[10] The size of the editions[11] varies from a few hundred to over a million, but most of them were of the order of magnitude of 1000 to 3000 The Department of Agriculture distributed a total of 62 2 million documents in 1918. I have no data at hand concerning bulletins of State bureaus, university bulletins, or the undoubtedly numerous publications not listed in Ayer's Annual, but their circulations are of the same order as for the scientific periodicals.

As I indicated at the beginning of this section by the example of the Chemical Society, the scientific-periodical type of printed matter is overwhelming in its bulk with reference to the producers of information, among whom it finds a large part of its circulation. At the same time, the extreme heterogeneity of the product and the extreme subdivision of its units of publication are its most outstanding characteristics The result is a very ineffective distribution of the information even among its producers

Praiseworthy efforts have been made to offset these disadvantages by means of abstracting periodicals, indexes, and guides But so great is the bulk of material that even the indexes and guides themselves are lost in the stream

So much for the producing class With respect to the general public the philanthropic-scientific-periodical type of literature is an almost negligible channel of distribution The usual circulation of a scientific periodical is about half a dozen copies per million inhabitants, a relatively minor ripple in the great current of wood-pulp Yet it is not quite as bad as it looks, thanks to the existence of abstracting periodicals and of public libraries The more important results of a research published in the *Journal of Physical Chemistry*, for example, with a circulation of only a few hundred, are reproduced in *Chemical Abstracts*, which, by means of its circulation of over 15,000 and its appearance in every important library of the country, may place the data before many thousands of persons [12]

The foregoing remarks concerning the bulk and heterogeneity of

[10] Estimated from data in W I SWANTON'S *Guide to United States Government publications* Bur Education Bull 1918, No 2. See also E. GUERRIER, *The Federal executive departments as sources of information for libraries* Bur Education Bull 1919, No 74.

[11] No published summarized data are available on this point An act of 1895 limits the initial edition of any departmental publication to 1000 Special acts provide for special publications or particular bureaus To supply large demands reprintings are permitted

[12] During the War a Library Information Service was maintained in Washington to keep the librarians of the country in touch with Federal publications Its future maintenance is dependent on the passage of a bill now before Congress (H R 6870 and S 2457)

philanthropic periodicals apply equally well to those published for profit, but there are some special features of the latter which require further consideration

The publication for profit of strictly technological periodicals (not trade journals) is a relatively recent development The most conspicuous example is the group of journals published by the McGraw-Hill Company They have the great advantage of being edited, managed, and circulated by men whose business is editing, managing and circulating periodicals, and nothing else. They do not suffer from the haphazard editing, inefficient business management, and almost neglected circulation characteristic of most scientific society journals At first rather looked down upon and avoided by scientific investigators, this class of periodicals now obtains, by contribution, special reporting, or reprinting, first-class readable material which it puts into the hands of readers at a comparatively small price

The scientific societies have apparently not become aware of the possibilities, both beneficent and dangerous, of these journals It is most important to recognize that their profit does not come from subscriptions, but from *advertising* Their problem, and likewise the problem they offer the community, is thus exactly the same as that of the popular magazine and the newspaper, they must publish just enough reading matter, of just high enough grade, to most efficiently carry the advertising, *and no more* What this amount and grade of reading matter shall be seems now fairly well established for the newspaper, but is still a subject of empirical experimentation by the popular magazine and the technical periodical published for profit, with extinction as the penalty for the ones that make the poorest guess.

This dependence upon advertising may even have the effect of making it good policy to *restrict* the circulation in certain directions rather than enlarge it, and thus make the journal actually work against rather than for the widest distribution of the information it carries The *American Machinist*, for example, probably costs in the neighborhood of twenty dollars per copy per year, yet it sells for \$4 00 per year Obviously, to send this journal to a professor of Latin, with no interest in and no buying power for machine tools, even though he be willing and eager to pay his \$4 00 for it, is to waste \$16.00, for the advertisers have no interest in supplying information to professors of Latin. This extreme case will serve to emphasize

the fact that it might even become unprofitable to send the *American Machinist* to any machinist but a master mechanic

In this connection I may note an interesting experiment now being made by the American Chemical Society. Considering the possible profit from advertising as well as the desirability of serving its industrial members, the Society in 1909 founded the *Journal of Industrial and Engineering Chemistry*, which has advertising and business offices, and an editor who devotes all his time to the *Journal* The profit from this journal in 1919 was such that the Society was enabled to do publishing and other work that would have required an increase in dues of $3.00 per year for its 15,500 members, had this aid not been available.

To summarize. Scientific and technological periodicals and bulletins reach the producers of information in overwhelming bulk The extreme heterogeneity of the material and its subdivision into many units of publication combine with this bulk to make them relatively ineffective distributors of information even to the producing class With respect to the general public, their small circulation makes them almost negligible as channels of distribution (with the possible exception of certain Federal bulletins of wide circulation), and public libraries can do little to offset this disadvantage, for the average library has not the facilities for handling them all The type of periodical which is published for profit is affected in all these respects by its dependence upon advertising

Separates [13].—In an effort to prevent the complete drowning and submergence of their work in the general current, many investigators during the last half-century have adopted the plan of getting "reprints" of their published work, and distributing these by mail to persons whom they know to be interested in the subject In recent years this method has even been adopted by some research institutions, such as the Geophysical Laboratory and the Mt. Wilson Observatory of the Carnegie Institution of Washington, and the Research Laboratory of Physical Chemistry at the Massachusetts Institute of Technology [14] A few organizations carry stocks of separates for sale (*e g.*, the Franklin Institute).

[13] Commonly (but incorrectly) called "reprints" in this country A better term is "offprints" (separata, extraits, Sonderabdrücke)

[14] Separates from periodicals are occasionally used by the Federal bureaus, for example, separates from the *National Geographic Magazine* by the U S Reclamation Service Separates from their own periodicals are also distributed, for example, from the *Journal of Agricultural Research* and the *Proceedings of the National Museum*

The publication of scientific periodicals in the form of loose separates which can be filed according to the taste of the subscriber has been suggested several times, and an actual trial of the plan was begun by the American Institute of Mining and Metallurgical Engineers in 1920. It is still too soon to judge of the advantages or disadvantages of the plan Somewhat similar is the loose-leaf type of serial literature best exemplified by *Lefax*

Popular magazines.—There were listed[15] in 1920 in the United States and Canada 139 literary, illustrated, and humorous publications of general circulation, most of them issued monthly; 33 "women's publications of home circulation," and 25 "mail order publications." In addition, there were 880 religious and 562 agricultural publications, mostly weekly. The aggregate circulation of the first group was about 22 million, and the individual circulation varied from 2.1 million down to 0.01 million The aggregate circulation of all was of the order of magnitude of 80 million, which, taking into account the number of weekly publications, is very probably equivalent to at least two copies per month for every inhabitant of the country,—numerically a very effective medium of distribution

The material published by these periodicals covers a wide range. A few are specifically devoted almost wholly to scientific information. Such are the *Popular Science Monthly, Science and Invention*, and *Scientific American Monthly*. Having circulations of 0.1 to 0.25 million, and appearing in all public libraries, this group reaches perhaps 2 million readers. The most striking example of success in this field, and one which proves the existence of an extensive public demand for information as well as for entertainment, is the *National Geographic Magazine* of this city, with nearly 0 8 million circulation.

Beginning with the scientific-informational type, these general periodicals may be arranged in order of decreasing amounts of information, ending with those made up entirely of fiction, fun, or gossip. As a whole, they supply a very large quantity of scientific information to the public, but the material is nearly as heterogeneous and disconnected as that supplied by the strictly scientific group.

With respect to producers of information, they play a very small part in distribution Seldom, if ever, do they announce the original results of research. They are under the necessity not so much of making a correct and understandable record, as of making a readable and interesting record, of discoveries. Hence their dependence upon

[15] Ayer's Annual, 1921

literary rather than scientific skill,—in other words, they must depend upon the middleman rather than the producer for their material

To summarize: The general monthly and weekly periodicals are at present numerically the most effective agency for the distribution of scientific information to the public; bulk and heterogeneity, however, discount their effectiveness as compared with books. They are a negligible factor in distribution to producers of information

Newspapers.—About 2400 daily newspapers were published in the United States in 1920, with a total circulation of about 31 million, or about one for every third person in the United States, *daily* There were also published some 13,000 weekly papers The possibilities for distributing information by this medium are thus tremendously greater than by any other of the methods we have considered

In spite of this fact the newspaper has hardly been utilized at all for the distribution of information Its contents are principally (1) advertising, (2) the news of the day, partly systematized, (3) repetitions and reiterations of that news in various forms, (4) opinions and predictions, (5) advice and propaganda, (6) fiction, (7) fun, and (8) gossip.[16] There are good reasons for the existence of all of these departments of the newspaper, and also for the absence of any considerable amount of real information. I shall not attempt to analyze these reasons, beyond remarking that the haste in which the newspaper is usually read is an important factor

One factor which we should consider, though probably a minor one, has been the information-producer's distaste for newspaper publicity. The teacher and the investigator, as a class, have inherited certain disabilities from past centuries, chief among which is that of being looked upon as akin to the medicine-man, monk, astrologer, or wizard. This tradition demands of the newspaper that the products of scientific investigation shall be "played up" in a corresponding form and most scientists have studiously avoided that insult to their self-respect—not a wanton insult, be it understood, but one demanded by the circumstances, just as vituperation is called for in a political campaign.

Of recent years, the knowledge-producing profession has increased greatly in numbers, and has accordingly come more intimately into touch with the world's every-day work. There is resulting a change

[16] I would include under this term much material which would come under the dictionary's definition of "news," but which has not the remotest relation to the interests of a given reader.

in the attitude of the public and the newspapers Serious efforts are now being made to increase distribution by way of the newspaper channel. One striking example is the geographical news service of the National Geographic Society of this city, which now reaches about 12 million people through its news bulletins. The American Chemical Society maintains a press service, with a salaried director, for the dissemination of accurate chemical information. Another experiment, about to be initiated, is being supported financially by Mr. W E Scripps. It consists of a 'Science Service'' for the newspapers, under the control of a board having a majority of scientific men who are nominated by the National Academy of Sciences, the American Association for the Advancement of Science, the National Research Council, and certain other organizations Mr E E Slosson, associate editor of *The Independent* and author of one of the best of the popular books on chemistry, has been appointed editor of the Service and will make his headquarters in Washington

Another experiment, of considerable local interest, was initiated last Monday, January 10, by the *Washington Herald*, in placing a special column at the disposal of Mr Watson Davis, a member of the staff of the Bureau of Standards who has had newspaper experience The column contains announcements and brief reviews of the papers presented before the Washington Academy and the scientific and technical societies allied with it It is a task requiring enthusiasm, persistence and conscientiousness, and I trust that the undertaking will meet with deserved success

To summarize The daily and weekly newspaper could become numerically the most efficient existing medium for reaching all the population, but has been very little used for the distribution of information in this country. The producers are too small a class to receive consideration, except in special localities such as Washington, while the general public has not been educated to demand the product through this channel

Distribution by the cinematograph —A decade ago we should have mentioned the moving picture as a useful adjunct to the public lecture Today "film" is said to be the fifth or fourth industry of the country The producers of film estimate that one person in every ten in the United States goes into a moving-picture house *daily*[17] It is probably second only to the printed page in its effectiveness as a means for the distribution of information, and there is some question as to whether it should not be placed first.

[17] E P OBERHOLTZER World's Work 41: 249–263. January, 1921.

There can be no doubt as to the superior appeal of pictures as compared with printed words When we multiply this superior appeal by the factor of motion, so that events are presented almost as vividly as if the observer were present on the scene, and still have available the factors of repetition at will, physical magnification to bring out details of form, retardation or acceleration of speed to analyze the motions, and finally, accessibility of the whole to a large number of people simultaneously, the possibilities of distribution by film seem almost limitless

The method is already in wide use for distributing information Its use as an adjunct to lectures has already been mentioned, but that use is now of secondary importance The showing of instructional films as part of a program for which people are willing to pay is not uncommon, as to whether it is increasing or not I am not sufficiently well informed to say Doubtless this feature of the movie program will have its ups and downs as has the informational article in the newspaper and popular magazine

Its philanthropic use is undoubtedly expanding Among the Federal bureaus, the Department of Agriculture, the Bureau of Mines, and the Reclamation Service have perhaps made the widest use of the method, having several hundred films available for loan.

I have briefly touched upon some of the salient features of the "pure components" of our methods of distributing information. These may be, and commonly are, combined in various permutations and combinations, which we cannot consider here in detail. I have also indicated certain directions in which each of our distribution methods fails in effectiveness, which brings us to our third question What of it?

III. THE EVILS OF INEFFECTIVE DISTRIBUTION

The years following 1914 have given an impressive demonstration of the ease with which man may relapse into barbarism, and have set a larger number of persons than usual to thinking on the problem of how best to insure human progress. Although few would publicly dissent from the thesis that to provide for the maximum possible *accessibility* of our nearest possible approximations to truth is a *sine qua non* of progress,[18] yet the survival and frequent approval of

[18] To go further and say that the widest possible *dissemination* is desirable implies a selection of material, since no individual can absorb all that is available, but this leads into the kind of discussion which soon goes aground on the irregular rock bottom of personal prejudices and ethical principles

such half-truths as "A little learning is a dangerous thing" show that the thesis is by no means universally accepted and acted upon. To argue this question here would be quite fruitless, since I have already shown that the number of persons who will hear and read this address is not only small, but drawn from a circle in which the thesis needs no demonstration I shall pass on to the more practical question What are you and I going to do about it?

IV. THE FUTURE OF THE DISTRIBUTION OF SCIENTIFIC INFORMATION

"A responsibility rests upon us to see also that the results of our own investigations are not buried more deeply than were the materials upon which they have been based "[19]

With this general sentiment we all agree. As to its particular application, probably each of us has his individual opinion That opinion should be based, not on prejudice or on our usual naive assumptions regarding human psychology, but on scientific information, much more accurate and detailed than the crude sample I have just been endeavoring to distribute.

In the following paragraphs I shall take up each of the methods of distribution already discussed, and indicate a few of the possible or probable directions of their future development

Personal communication —There is no improvement to be hoped for from this method of distribution. Indeed, as I have hinted before, we need less of it rather than more. If men especially fitted by temperament and training to do original research are employed with the expectation of devoting their whole time to the task of digging out new knowledge, they should not be expected to spend time and energy retailing that knowledge

I have already referred to complaints by the Government's scientists of the wasting of their time in answering miscellaneous questions This is not indolence, narrow-minded selfishness, or lack of public spirit on their part, any more than it is selfish for the President of the United States to refuse to give his whole day to receiving visitors, he has other important business to attend to

Various results follow if the investigator is not protected by the administrative part of his organization against too much questioning One effect is that he does as much of his research as he can at home, or in some obscure corner where visitors cannot find him; but this inter-

[19] J C MERRIAM *The research spirit in the life of the average man* Science 52: 473–478 November 19, 1920

feres with the "team work" necessary to make an *organization* successful, as such. Another effect is to drive him altogether out of public or philanthropic research into industrial research, where it is commonly assumed (whether rightly or wrongly I do not venture to say) that "silence is golden."

The above remarks do not apply, it hardly need be said, to the personal exchange of information among investigators, this is a part of the process of production rather than distribution.

The informational middleman—Once in a while it happens that an individual who has undertaken to do research finds the personal retailing of information much more to his taste than the slow and tedious and discouraging task of digging it up He should by all means be given a chance to utilize the talent, with a corresponding release of burdens on the research worker. Some of the Federal bureaus already have what might be called "secretaries for foreign affairs" who stand between the bureau and the public, but I believe their functions could be profitably enlarged, the large proportion of simple and oft-repeated questions which comes to them might be transferred to a central bureau of information representing all the scientific bureaus, which might also handle that most time-consuming of all inquirers, the "harmless crank"

The large research foundations are so new that the public is not yet widely aware of their existence as sources of knowledge, or, when it is aware of them, assumes that they are manufacturing something tangible and salable As they become better known, however, they will have to provide some organization for answering questions, for they are public institutions in an environment which is relatively unsympathetic, and considers them all too frequently as possible sources of alms but of little else They cannot afford to overlook any method of enlisting public confidence

The retailer of information for profit is also likely to increase in numbers in the future. In the field of medicine, for instance, it is now possible to consult the diagnostician who reports facts only and offers no treatment or advice, and this kind of service will increase with the increase in medical specialization. We may even perceive a kind of wholesale and retail system in the course of development, the wholesale distribution being through specialized bureaus by way of technical publications to which the public has little if any access, but which the information office digests and retails to its inquirers Various commercial information bureaus in Washington, such as that of F. J. Haskin, perform this kind of service.

In general, the most hopeful possibilities for improving the distribution of information lie in the direction of increasing the numbers and improving the training of the informational middleman.

The public lecture.—The philanthropic lecture as now employed is extremely wasteful and inefficient. Lack of cooperation between small organizations frequently causes duplication of a lecture in the same city, both times to small audiences An invited lecturer will travel long distances over the same railroad to neighboring cities, to an extent that would astonish a Keith-circuit organizer We can improve this situation by ourselves insisting on the principles that the original investigator, when asked to present his work, be given an opportunity to reach as wide a circle of interested persons as possible, and that after he has thus presented it he be relieved from duty as a mere entertainer, unless he enjoys lecturing and does it for recreation or training

The presentation of information at general meetings of the scientific societies is capable of improvement in many ways, and has been the subject of considerable experimentation, but I shall not attempt its discussion here

A recent development which may be of great significance is the distribution of public lectures by wireless telephony

The museum and exhibition—I have already referred to the evolution of the modern museum in the direction of becoming much more of a diffusing agency, and less of a collecting, examining, and storing agency This work will doubtless be extended by the loaning of exhibits and the formation of traveling exhibits The museum is already combining other agencies, such as lectures, printed bulletins, and moving pictures, with its own particular method of distribution and this expansion may also be expected to continue It has not yet, as far as I know, seriously attempted to combine with itself anything resembling what I have called the "informational middleman" for the personal retailing of information, except occasionally in connection with special exhibits This is a development which we may expect in the future

Books—The best way to get information on an unfamiliar subject is by a personal interview with somebody who knows, and the next best is to go to the encyclopedia. In either case, one is likely to strike a trail which leads to a specialized book on the subject If it is a book made and sold for profit, the course is clear. But if the

book is distributed philanthropically, it is much less easy to obtain Considerable correspondence may ensue to find it, unless the seeker is in a hurry, in which case he engages the services of a book-dealer and pays for the service. If the book has been issued free by a Federal bureau, with the hope that it will reach as many as possible who are interested, it might seem that the Government would welcome such assistance, especially when the consumer is willing to pay for it Yet the Haskin agency, which distributed 1 3 million government publications in 1918–1919 at no more than the cost of postage, was severely criticized in the Senate by Senator Smoot,[20] and with it the bureaus who permitted themselves to be thus aided The tendency of the next few years seems likely to be toward restriction rather than enlargement of free Federal distribution

It goes without saying that the free distribution of books to all involves tremendous waste Our Federal and State governments have been the most prodigal in the world in this matter The law requires that reasonable care be exercised to prevent waste but the law is difficult to administer

An obvious remedy is to sell the publications "at cost" But what is cost? At the end of 1919 the Carnegie Institution of Washington[21] had expended on research 11 9 million dollars, and had published 401 works, with an average edition of about 800, or a total number of volumes of about 327,000 If we assume that half the work of the Institution has been thus published, the cost per volume is about $18 00 As the books could not be sold in any number at this price, the price has been fixed at a figure which will represent the cost of paper, printing, and binding As a basis for distribution this is admittedly unsatisfactory, for the value of a book cannot be measured either by its total cost of production or by the cost of printing and binding it Some of the works were sold out long ago, others move but slowly, and diminish in real value the longer they remain in storage

Any system of distribution for books published philanthropically should recognize the distinction I have endeavored to draw between production and use. Producers of knowledge may well be given the fullest possible access, by personal conference, free or purely nominal-priced books, and every other means of distribution, to the new knowledge in process of being obtained by other producers To

[20] Congressional Record, April 2, 12, and 22, 1920

[21] Year Book, 1919

grant the same privileges to those who are mainly consumers might, as I have indicated before, swamp the whole process of production.

Scientific and technical periodicals.—Concerning much that is published in our voluminous scientific and technical literature we might reasonably ask, as the Mock Turtle did of Alice, "What *is* the use of repeating all that stuff?" If we had an all-wise censor to judge it, we might well dispense with the greater part of it. But in that "if" is contained the whole argument against any kind of suppression

There is instruction, and perhaps encouragement, in comparing the evolution of scientific periodicals with that of newspapers and popular magazines The newspapers began with small local circulations at a few places They increased in numbers, and a few papers forged to the front and became leaders, widely read or quoted from The multiplication of local papers, however, did not cease, but increased, until now every hamlet has one; their diversification, to represent many groups of people with related interests, went on simultaneously. Of recent years, a strongly marked tendency toward financial and operational centralization has appeared

Other types of periodical printed matter have gone through a similar evolution, and scientific periodicals are following along in their turn We have had (1) the period of early growth, and small circulation, but large influence, and (2) the period of greatly increased circulation of recognized leaders, with precarious existence for the smaller members; and we are just entering (3) the period of rapid multiplication of local scientific periodicals together with minute diversification according to specialties. The period of centralization is still below the horizon

It may be urged that science is universal, and a *local* scientific publication is an anomaly, then so is a *specialized* journal, for knowledge is no more to be divided into compartments according to the temporary interests of human beings than according to their geographical residence. Nevertheless local and specialized newspapers, magazines, and scientific journals multiply in spite of logic. Every group of a few hundred or a few thousand persons with allied interests, whether allied by profession or by geographical location, seems to need its printed organ, and the feelings of librarians are given no consideration whatever The Washington Academy of Sciences, for example, representing in its own membership and in its affiliated societies nearly 3000 scientific and technical men and women, with

certain joint interests that are local and not divided according to sciences, finds a demand for a journal which shall represent those joint interests in news, society proceedings, and announcements of the research going on in the city, and strives to fill that need; it may not always be perfectly filled but it is there.

As the number of periodicals relentlessly increases, the need for efficient and thorough abstracting and indexing is being more and more felt and provided for. For example, chemistry and a large part of physics is being admirably served by Mr. Crane in *Chemical Abstracts*. Geology and allied sciences are excellently handled by Mr Nickles in the annual index issued by the U. S. Geological Survey. Indexing and abstracting is a developing art, which should not be left to amateur bungling, but should be turned over to individuals trained and well paid for the work.

The relation of advertising to scientific and technical journals is a matter of especial interest It is said that any periodical which can attain a circulation of 5000 or more can support itself on advertising. Why should scientific periodicals not make better use of this fact?

I have already mentioned the Chemical Society's experiment with the *Journal of Industrial and Engineering Chemistry*, which returns from its advertising a considerable revenue to the Society Now there is nothing in this situation to abrogate the old rule that "No man can serve two masters" If the time ever comes when the interests of the Society and the interests of the advertisers come into conflict, the *Journal* either will have to stand by its advertisers or will have to change its character Naturally, both the advertisers and the Society will seek to avoid occasions which would lead to disagreement; but that is only another way of saying that the advertisers will exert a considerable influence on the policies of the Society, whether they wish to or not

The situation is further complicated by the existence in the same field of the periodical *Chemical and Metallurgical Engineering*, which is published for profit and not as the organ of any society It has the advantages over the *Journal of Industrial and Engineering Chemistry* (1) of publication weekly instead of monthly, making its news much fresher and therefore more in demand; (2) of freedom to use its own income for its own purposes, not for carrying another organization on its back. The *Journal*, on the other hand, (1) has the prestige of representing the largest chemical society in the world and

(2) has the first claim on the material presented before that society. In my opinion, the *Journal* now publishes a higher grade of material, but the *Engineering* has been steadily improving. The *Journal* has the larger circulation by about one fifth Each claims that it has a circulation more profitable to the advertiser than the circulation of its competitor, but on these claims I am not competent to give any opinion

There is evidently staged here a contest of the social versus the profitable which I, for one, will observe with interest during the coming decade Meanwhile, without seeking to condemn or approve either side, I believe we shall do well to keep these facts in mind when considering contributing articles to these journals or others similarly situated.

The progress of experiments such as I have described may not improbably result in scientific societies finding it to their advantage to have all their *publishing* done for profit, just as they now have their printing and binding done for profit. Why not turn the whole conduct of their publications over to an organization which makes a business of editing, managing and circulating periodicals, subject of course to some original control by each society as to the general nature of the papers to be published?[22]

One benefit which would result would be the saving of time and energy of investigators now spent on routine editing and publishing The amount of good research which has been prevented by scientific periodicals would probably be appalling if we could sum it up Another benefit would be the suppression of a great deal of data now being published simply because space happens to be available but for which there is not and never will be any demand. On the other hand, the work of a Willard Gibbs might also be suppressed [23]

Another point regarding advertising We all recognize that the consumer pays for it, yet he has little if any control over what he has paid for The manufacturer tells him what the manufacturer would like to have him know, and no more Why should not the consumer have his advertising page, in which to tell the manufac-

[22] An experiment of this kind is about to be tried by the Chemical Society with its two series of Scientific and Technologic Monographs, by contract with the Chemical Catalog Company of New York

[23] On second thought I find I have selected a bad example If the *Transactions of the Connecticut Academy* had not been available, Gibbs' work might have been offered and published where it would have really circulated, and the English-speaking world would not have had to wait for it to be translated into German before it could become known.

turer what he wants, and in which to tell his fellow-consumers his experience with what had been offered? The editors of the *Journal of the Washington Academy of Sciences* have considered the feasibility of publishing "consumers' advertising" of this kind, since the Academy, as a private organization with no governmental or commercial affiliations, is in a wholly disinterested position, and furthermore numbers in its membership representatives of almost every ramification of science so that a wide range of experience is available. The task of "advertising manager", to collect, edit, and publish material of this type, however, is one of those public services which are more praised than rewarded.

Newspapers and popular magazines—The appearance of scientific information in newspapers and popular magazines is relatively so recent that it would be rash to try to predict its future. These media themselves may change considerably during the next two decades The present tendency toward centralized ownership and management of both types probably bodes good rather than ill for the distribution of information, whatever may be thought of the tendency in its political and social bearings

Separates—The use of separates seems to be on the increase, and I believe is destined for continued growth In particular, their use in place of special series of "bulletins" published by research institutions is a very desirable development Bulletins issued in independent series are not likely to be effectively distributed, as each has to be handled by itself and librarians are frequently at a loss as to where to index or file them Their very existence, also, may remain unknown until long after the stock has become exhausted and copies are no longer available for libraries which find them in demand. Articles published in a regularly circulating journal, on the other hand, are not thus lost to view or rendered inaccessible The difference is the same as that between the privately printed book and the book issued by a publishing house which is always in touch with the channels of distribution

The distribution of separates by dealers is a service almost lacking in this country. For instance, before the War the surest way to get a separate of an American geological paper was to write to Leipzig for it Patriotic pride, if nothing else, ought to stir us to remedy this situation. Some authors deliberately send copies of their separates to the second-hand dealers in order better to reach interested persons unknown to them; while others condemn this practise as undignified

Printed matter in general.—I have reviewed briefly certain phases of the distribution of information by the printed page. There remains another point of view from which to consider all of them

To distribute information by printing it is necessary first, to place the printed article in the reader's hands; second, to induce him to *read* it, rather than file it or put it in the waste-basket; third, to present the matter so that the reader gets some profit from his reading.

The members of the advertising profession are probably the best fitted to instruct us as to the best way of putting reading matter into peoples' hands, but I do not happen to know of any scientific organization which has actually utilized their experience The organizations best known to me are experimenting, each with its own system, and the results will after some years be valuable as comparative experiments Present tendencies in the distribution of free or nominal-priced publications seem to be in the direction of the periodical issuance of lists or announcements of publications to a large mailing-list, the recipient being expected to make his own choice and go to whatever trouble is necessary to obtain the publication Details of the process vary widely, and the future will see the elimination of the less effective procedures

The second problem, that of inducing the recipient to begin to read what he has received and perhaps has even personally asked for, calls, in the commercial field, for the highest art of the advertiser I doubt whether this phase of the question has ever been given much serious consideration by the distributor of scientific information, though it is the very life of modern printed advertising. Certainly the Federal bulletins coming from the Government Printing Office all look alike, and I question whether all of them would be called "attractive" by the commercial printer. I feel that we would do well not to be satisfied with the dictum that "information is information and the consumer may take it or leave it"

The third point, of presenting the matter so that the reader gets something for his pains, is where the investigator himself is put on his mettle I have presented his complaint against too much questioning, but there is no intention of relieving him from the duty of giving a clear account of his product, *in writing* The account need not be non-technical or suited for general reading, but it should be understandable with the minimum of effort by the circle of readers for whom it is written. Here is where the investigator most often fails. Dr. George Otis Smith, director of the U S. Geological Sur-

vey, has made it one of his favorite subjects of discourse to urge that the results of investigation be stated in clear and easily understandable language, and to point out that muddy writing is usually the product of muddy thinking He provides, for his organization, an editor who gives his whole attention to improving the readability of the Survey's publications. Most organizations have editorial committees, sometimes seeming to ramify ad infinitum, but current discussion and comment lead me to believe that the less of this kind of committee work we can get along with, the better A more practical system to work toward may be indicated in the fable of the successful publishing house which passed for publication only matter which was found to please the janitor

If the investigator neglects his plain duty of presenting an accurate and clear account of his results (though not necessarily non-technical or adapted to the use of the public), and his organization neglects its duty of seeing that the account is readable and accessible, then there is little ground for complaint on their part if the work is overlooked and even duplicated by somebody else Although it is perhaps contrary to existing professional tradition, I feel that "a thorough knowledge of the literature" is not incumbent on an investigator if a part of that literature is so obscure as to require a disproportionate time for its discovery and deciphering [24]

The "movie" film.—The future of the distribution of scientific information by the "movies" is simply beyond prediction Perhaps its recent vigorous growth is only that of a mushroom, without permanence Rapidly increasing investments in the business, on the other hand, indicate considerable confidence in its future Progressive educators, also, are fully aware of its possibilities, as indicated by the recent formation of a "Society for Visual Education." One thing is certain. that the best results will not be attained by leaving the matter to the ruthless natural selection of commercial competition Neither will anything serious be accomplished by considering the moving picture as merely an adjunct to the lecture or museum

Other methods—A minor method of distribution, used particularly in crystallography, physiology, paleontology, and geography, is that by models or casts made in any desired number from a mold Its

[24] "It is the worst of educated men that they cannot speak about any great question till they have read everything that has been written about it, for fear that some one should say, 'But have you read Schwartzenburg?' Then, if they have not read Schwartzenburg, they are done "—TOLSTOY

use could well be extended to other sciences. Phase-rule models in chemistry, for instance, concentrate a great deal of information into a small space and put it into a form very useful for instruction.[25] Another minor method is the distribution of type collections of material, made up in considerable number from a common supply, and distributed usually by sale. This has been used in the fields of mineralogy and petrology and certain branches of biology Collections of photographs have been similarly used by some of the Federal bureaus. The number and field of usefulness of such reproducible collected sets of material objects is likely to be enlarged

The general problem of distribution to the public—I have referred repeatedly to the "bulk" and "heterogeneity" of our present output of scientific information, and hope that by inference as well as by direct statement I have already impressed the idea that haphazard dissemination does not constitute orderly distribution.[26] We have accomplished little if we have merely reached the auditory or optic nerve of the public without reaching its understanding Have we any assurance, for example, that the Science Service for the newspapers (after performing its obvious and useful duty of preventing misinformation) will do more than merely replace on the newspaper page an equivalent area of advice, gossip, or fun, producing about the same permanent effect as the displaced material? I hope the plans of the Service will include some method of measurement of its permanent results, for, in chemical terms, if there is no solubility there will be no absorption, however large we make the area of contact, and if the absorption turns out to be small we shall have to do something to increase the solubility [27]

In conclusion, I wish to express my indebtedness to various members of governmental and private institutions in Washington for assistance and suggestions in the preparation of this address

[25] The Geophysical Laboratory has received a number of requests for copies of its models of silicate systems, but is not equipped to manufacture and sell such a product Some commercial or philanthropic agency would do a service by taking up this kind of distribution

[26] *Dissemination* "Propagation by means of diffusion or dispersion Propagation by means of promulgation, a spreading abroad for or with acceptance, as of opinions" (Century Dictionary) The disseminator selects what is to be promulgated and the public is at his mercy *Distribution* "Allotment in shares or according to requirements The division of the aggregate produce of the industry of any society among the individuals who compose it" The public does the selecting and the distributor renders the product accessible.

[27] "One can readily conceive a Dark Ages which was such because of too much instead of too little information" The Villager 4: 94. November 6, 1920

GENERAL SUMMARY

The production of new information in the United States is much better managed than its distribution It is distributed through five main channels (1) by personal communication or through the "informational middleman," (2) by public lectures, (3) by the museum and public exhibition; (4) by the printed page—books, scientific and technical periodicals, bulletins, general periodicals, newspapers, and separates, (5) by the cinematograph Ineffective distribution results from (1) disinclination to use new knowledge, a cause not discussed in this paper, (2) the inaccessibility of scientific information, arising from (*a*) the bulky form in which it comes from the producer, (*b*) its heterogeneous character, and (*c*) the arithmetical or psychological limitations peculiar to each method of distribution The bearings of these various factors on existing methods of distribution, both to producers of information and to the general public, are touched upon, and desirable or probable future developments in each are briefly discussed.

SCIENTIFIC NOTES AND NEWS

A reception was held on January 12, 1921, by the President and officers of the Medical Society of the District of Columbia to the members and friends of the Society, including the members of the ACADEMY and its affiliated societies. The reception was held at the new home of the Medical Society at 1718 M Street, following the dedication of the building.

The Washington Section of the American Institute of Mining and Metallurgical Engineers held a supper and meeting at the Interior Department on Friday, January 14. Dr. H. FOSTER BAIN, the newly appointed director of the Bureau of Mines, lectured on *Mines and mining in the Far East.*

The National Museum has received specimens of various deep-water fishes from Hawaii, which had been killed by the recent lava flow from Mauna Loa. Most of the forms have been found by Dr. D. S. JORDAN to be new, and a report on them will be published by the Smithsonian Institution.

An exhibit of medicinal substances arranged according to their therapeutic effects is being prepared for the Division of Medicine of the National Museum.

Dr. J. M. ALDRICH of the National Museum was elected president of the Entomological Society of America at the Chicago Meeting.

Col. J. M. BIRCH of the British Army, in charge of the agricultural development of the Mosul district of Mesopotamia, has sailed from New York after spending several months studying American agriculture. While in Washington he used the facilities of the Bureau of Plant Industry.

Dr. H. C. BRYANT and Dr. L. H. MILLER, of the University of California, have been spending some time in Washington, and delivered addresses before the Biological Society on January 22, and the Audubon Society on January 26. Doctors Bryant and Miller were nature guides in the Yosemite National Park during the summer of 1920 and organized field trips for the instruction of visitors.

Dr. H. L. SHANTZ has been appointed plant physiologist in charge of Plant Physiological and Fermentation Investigations in the Bureau of Plant Industry. Dr. Shantz returned in September from a year's trip through Africa for the Office of Foreign Seed and Plant Introduction, from which office he is now transferring.

Senator CHARLES S. THOMAS, of Colorado, resigned on January 5 as a Regent of the Smithsonian Institution, and the Vice-President appointed Senator A. O. STANLEY, of Kentucky, to succeed him.

Mr. W. F. WALLIS, of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, left Washington on January 9 for Huancayo, Peru, where he will succeed Dr. HARRY M. W. EDMONDS as magnetician-in-charge of the Huancayo Magnetic Observatory upon the conclusion of the latter's two-year assignment. Dr. Edmonds will return about April via San Francisco for duty at Washington.

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RADIOTELEGRAPHY.—*The wave front angle in radiotelegraphy.*[1] L. W. AUSTIN, U. S. Naval Radio Research Laboratory.

One of the outstanding problems in radiotelegraphic transmission is the determination of the angle between the advancing wave front and the earth. A number of physicists[2] have treated the subject theoretically and a resumé of their conclusions may be found in Zenneck's *Wireless Telegraphy* (translation 1915), pp. 246–253 The subject is of great importance in the theory of transmission and has a very practical interest in the reception of signals on ground antennas.

Several experimenters have attempted to measure the wave front angle by means of receiving loops, the method being to rotate the loop around a vertical axis to the point of minimum signal and then to rotate again around a horizontal axis in the plane of the wave front until silence is obtained. A little consideration will show that this method is not applicable to the problem, since after the minimum is obtained by rotation about the vertical axis, none of the magnetic lines of the wave can thread the loop no matter what its angle in reference to the wave front, any residual effect in this position being due to the action of the loop as an antenna.

The most obvious method for measuring the angle, and the one which seems most free from objection, makes use of a pivoted straight wire antenna system well elevated above the ground with a receiver inserted in the middle. The general arrangement is shown in figure 1, and the method of shielding the circuits in figure 2 The antenna consists of two collector wires, each 30 feet long, supported on a pivoted wooden spreader (Fig. 1) 60 feet long, mounted at the top of a 55 foot wooden pole so as to be capable of rotation about a hori-

[1] Received December 20, 1920

[2] J ZENNECK, Ann Phys 23: 846. 1907 K ULLER, Jahrb 2: 8 1908 A SOMMERFELD, Ann Phys 28: 665. 1909 P EPPSTEIN, Jahrb 4: 176 1910

zontal as well as a vertical axis The receiving set consists of a primary inductance and parallel capacity connected between the two collectors as shown in figure 2, and a secondary, generally of the magnetic back-coupled oscillating vacuum tube type, provided with a two-stage audio frequency amplifier, though in some experiments a radio-audio amplifier with heterodyne was used. The whole set including the batteries was mounted on top of the pole

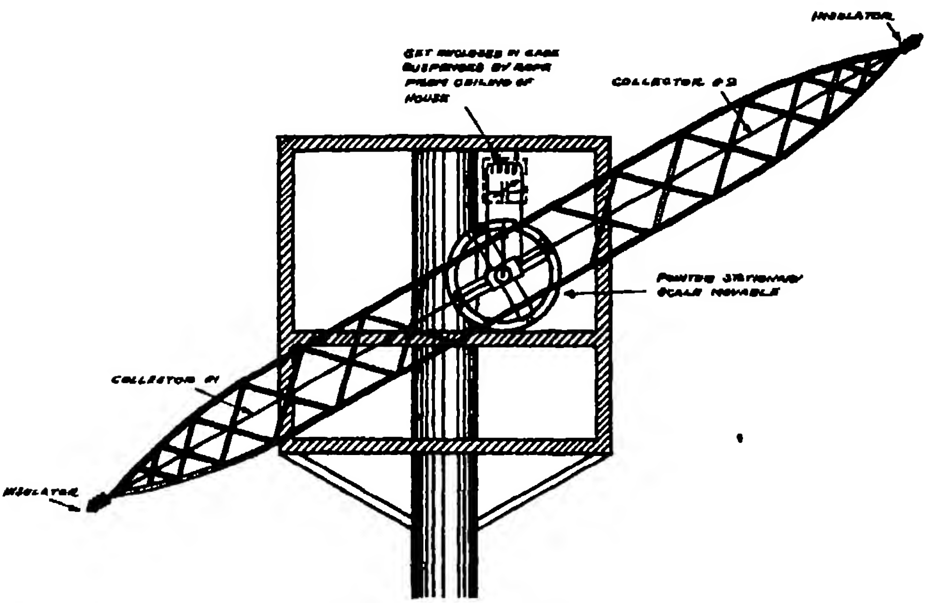

Fig 1 Diagram of pivoted straight wire antenna system, mounted on top of 55 foot pole

The method of experiment is as follows The antenna is first set vertical with the horizontal axis approximately in the plane of the wave front This gives maximum signal. It is then rotated about the horizontal axis and as the antenna approaches the horizontal position the signal fades as on an ordinary radio compass At some angle it dies out, and then as the rotation is continued comes in again At the mean of the two positions of just audible signal, the antenna is perpendicular to the wave front if there are no causes of distortion. The antenna is next rotated through 180 degrees and two more angles of disappearing signal are observed. The mean of the four observations should give the determination with considerable accuracy.

In the final experiments the mast with its pivoted antenna and instruments was erected on the Anacostia Flats not far from the Washington Navy Yard The absence of wire lines and houses within

a distance of more than a quarter of a mile made this an ideal location for the work. The two collector wires of the antenna were stretched in a straight line by the spreader shown in figure 1 This was constructed of wood with its joints fastened by wood dowel pins and a few brass screws The scale for determining the angle was aligned with the wires by means of a transit. All the apparatus, with the exception of the primary inductance and condenser, was contained in a box covered with fine mesh copper screen This box was supported by ropes in order to reduce the capacity between the receiving set and the mast It was also found necessary to shield the telephone leads and ground the head band to the copper screen surrounding the apparatus.

At first a certain asymmetry was observed in the reading when the antenna was turned through 180 degrees This was apparently due to an asymmetry in the capacity between the grounded shield and the two collector wires, and was corrected by connecting a small compensating condenser between one side of the primary and the shield This condenser also produced a much sharper minimum Its action is similar to that of the compensating condenser frequently used with the ordinary radio compass Figure 2 shows the method of coupling the primary to the secondary, the magnetic field passing with some loss through the shield while the static field is cut off The primary and compensating condensers were supported by cords in order to reduce the capacity between them and the mast The antenna collectors and all the instruments were thoroughly insulated The reversing switch in the primary in figure 2 allowed the collectors to be reversed without actually turning the antenna through 180 degrees. With strong signals it was necessary to turn the primary coil parallel to the plane of the oncoming wave and correctly adjust the compensating condenser in order to prevent the signals being heard with the collectors disconnected This precaution is of importance, since any signal picked up by the instruments not only blurs the minimum but displaces it.

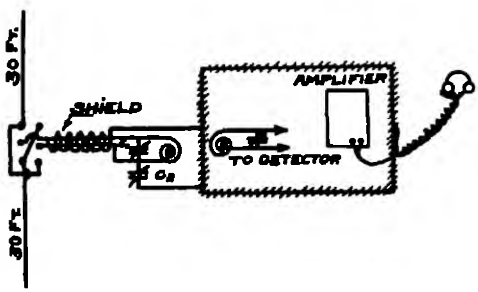

Fig 2 Method of shielding circuits

It was originally intended to continue the observations for several months so as to make an extended series of measurements on stations

lying in different directions, at different times of day and different seasons of the year. Preliminary observations had been made at the Bureau of Standards in the summer and autumn of 1919, using a lower pole, shorter collectors and less efficient screening, so that the possible errors of observation at that time were not much less than 10 degrees. During this time a large number of observations were made on various stations including New Brunswick, Annapolis, Nauen, Lyons, San Juan and Darien, but in no case were any deviations of the wave front from the vertical found which were greater than the estimated errors of observation The work with the final apparatus at Anacostia had been in progress only a short time when it became necessary to remove the pole as it was considered dangerous to the aviators at Bolling Field.

Daylight observations

The results obtained during this period are given below. While they are not as extensive as would be desirable, they probably fix a definite limit to the deviations of the wave front from the vertical for the stations measured, under conditions of normal daylight reception. A great number of measurements were made on the near-by stations, New Brunswick and Annapolis, largely as a test of the accuracy of the apparatus, as it was assumed that the wave front at these distances would be practically vertical. New Brunswick showed an apparent bending forward of the wave front amounting to 3.1°, while Annapolis showed an apparent bending back amounting to 2.2°. These apparent deviations are considered as probably due to systematic errors of the apparatus, depending apparently on the direction of the horizontal axis

TABLE 1 WAVE FRONT ANGLES, JUNE, 1920

Station	Distance in nautical miles	Wave length in meters	Apparent angle of wave front mean	Number of sets of observations	Maximum deviation of any set from mean
New Brunswick	152	13,000	+3.1°[a]	44	+1.4°
Annapolis	29	17,200	—2.2°	14	+1.2°
Nauen	3595	12,500	+3.4°	3	—0.4°
San Diego	1974	15,200	—0.8°	1	+1.3°

[a] The plus sign indicates a forward sloping wave front

The chief interest in the experiments was of course centered in observations on stations at a great distance. A number of observations were made on Nauen of which the average is given in table 1. It is seen that the deviation from the vertical is only slightly greater than the estimated error. On one day measurements were also obtained on San Diego. This observation is of especial interest because

in this case the waves passed over land for the whole distance, which might be expected to produce a marked tilt in the wave front. The table shows, however, that the wave front according to the observations is almost exactly vertical.

Night observations

On account of the well known shift of the apparent direction of New Brunswick as observed in Washington at night, an attempt was made to discover whether there was a similar shift in the angle of the wave front This was of interest since the most usual explanation of the apparent shift in direction assumes the arrival at the receiving station of a portion of the energy by reflection from the upper atmosphere. During the observations in the autumn of 1919 with the preliminary apparatus, experiments were carried on throughout one night, while at the same time the apparent deviation in the direction of New Brunswick was observed on the radio compass No certain deviation of the wave front was found, while the apparent direction of the station shifted at times by as much as 30°. Observations were also made every ten minutes from 5 45 p. m to 11 45 p m on June 14, using the final apparatus, but no certain deviation in the wave front angle was observed at any time

Comparison of the vertical and horizontal intensities of the wave

The problem of the wave front angle may be attacked in another way If we are able to measure the received currents from a distant station in an ordinary vertical antenna and in a ground antenna, we can calculate the wave front angle since the electric intensity (volts per meter) must be proportional to the projection of the wave on the vertical and horizontal planes [3] Observations have been made which show that an antenna 2000 feet long in fresh water receives the signals from Nauen at a wave length of 12,500 meters with the same intensity as a vertical antenna having an effective height of 50 feet, the resistance of the vertical antenna system being approximately 50 ohms and the water wire approximately 100 ohms

Since the strength of the telephone currents is proportional to the square root of the antenna watts, the field expressed in volts per meter is twenty-eight times as strong in the vertical plane as in the horizontal, which would correspond to a deviation from the vertical of approximately 2°. This, it will be seen, lies within the estimated

[3] This method may perhaps be criticized on account of the unknown effects of the earth currents surrounding the ground antenna

limits of error of the pivoted antenna measurements and the results of the two methods may be considered to agree

We may therefore assume in conclusion that for wave lengths over 10,000 meters, the deviation of the wave front from the vertical under ordinary conditions at Anacostia does not much exceed three degrees.

Static

With the new apparatus it was possible to obtain the angle of the wave front of the static disturbances with considerable accuracy It was found, contrary to the hypothesis that static comes from above, that the static wave front is always practically vertical like the signal, but that at times the two angles differ sufficiently to give a readable signal on the static minimum

Preliminary observations in this work were taken by T H Willey, Electrician, U S N , while observations with the final apparatus were made by L M Clausing and W F McBride

ZOOLOGY —*The nomenclature of supergeneric names* [1] S A. ROHWER, Bureau of Entomology.

The recent article by Dr Harry C Oberholser[2] on the nomenclature of supergeneric[3] names is by far the most comprehensive treatment of the subject which has been published, and should form the basis for a discussion of the subject which will lead to the establishment of satisfactory rules covering this important question The adoption, as a part of the International Code, of any comprehensive and uniform set of rules is most certainly to be accompanied by the change of many supergeneric names and the matter should be considered by students in all groups and an effort made to preserve as many of the best known names as possible

Dr Oberholser has made reference to the Hymenoptera at a number of different places in his article and it seems worth while to point out certain overlooked points and show how the rules which he recommends would work in certain groups within this order On page 144 he implies that modern entomologists have endeavored to follow the plan of naming the family after the oldest included genus, and

[1] Received January 6, 1921

[2] *The Nomenclature of Families and Subfamilies in Zoology* Science, n ser **52**: 142–147 1920

[3] I have used this term because I wish to include superfamilies, families, subfamilies, tribes and subtribes

apparently overlooks the fact that in the most recent catalogue of Hemiptera the author has been guided by the rule of priority in selecting family names. In the Hymenoptera there has been no fixed rule governing the selection of supergeneric names but by far the greater number of taxonomists have formed the names from the oldest included genus, and some of the most apparent exceptions which occur in recent catalogues are caused by the authors of these catalogues accepting only part of classifications or by their placing different values on certain supergeneric groups

In his arguments for what he calls the "permanent type genus" rule, Dr Oberholser advances the belief that for Hymenoptera Dalla Torre has catalogued all the family and subfamily names, and with this as a basis it would be comparatively simple to adopt this principle This is hardly true, and when one contemplates adopting the law of priority for the selection of supergeneric names, he loses much of his enthusiasm as soon as he sees the labor and difficulties involved in cataloguing these names Dalla Torre's "Catalogus Hymenoptorum" gives only a few of these Supergeneric group names have been used not only in taxonomic papers but also in local and faunistic lists, catalogues of collections and in biological and anatomical papers There has never been any serious effort made to index all these names, in fact many of the papers containing them are of such a local or ephemeral nature that only the titles are recorded To adopt this principle would mean that we should have to go completely through the vast literature dealing with Hymenoptera and when this task was completed we should still be in doubt because of the possibility of overlooking papers Such work would require considerable time and could only be done in large libraries After such researches were completed it would be necessary to publish the results in full, so that in case other students should wish to subdivide existing groups, they would be able to determine if a name had ever been proposed for a similar group or a group containing some of the same genera as those they included in their unit Of course it may be argued that it would not be necessary to catalogue all papers and that we should only include those which are purely systematic, but such a plan would be unsatisfactory because it would envolve a decision as to what was "systematic" and might eliminate such useful lists as those prepared for the various editions of the Insects of New Jersey.

From the above it might be understood that I do not favor the adoption of the method approved by Dr Oberholser, and this is in a

large part true. The idea he defends is undoubtedly logical, it encourages and necessitates the study of the history of classification, but it is beset with certain practical difficulties. The application of the principle of priority would bring about some curious changes of which the following may serve as an example

The genus *Bracon* is the type genus of the family Braconidae and should also be the type genus of all minor divisions of the family in which it is included. The application of the rule of priority and the other rules advanced by Dr. Oberholser would make this last impossible. Years ago the family was divided into subfamilies and these subfamilies were given names formed on the root of one of the generic names included The students who proposed these names paid but little consideration to genotypes and their subfamily Braconinae was founded on their conception of the group *Bracon* rather than the genus of the genotype. The genus *Bracon* of the genotype belongs to a different subfamily, termed "Agathinae," which was proposed at the same time as the subfamily Braconinae According to the law of priority the subfamily name Agathinae must hold for the group (because the name of its type genus (*Agathus*) remains unchanged) even though the genus *Bracon* is added to it; and the name of the old group Braconinae must be changed to Microbraconinae, and have as its type the generic name which replaces *Bracon* of authors (not the genotype) Perhaps the following summary will make this clearer:

Braconidae.

Braconinae Marshall, 1887 = Microbraconinae.
  Type.—*Bracon* Auctt. nec Fabricius = MICROBRACON Ashmead
Agathinae Marshall, 1887
  Type - *Agathus* Latreille, 1805
  Includes—*Cremnops* Foerster, 1862 = BRACON Fabricius, 1804

Hymenopterists have not followed the above but have formed the subfamily names on the oldest included genus and thus have a subfamily Braconinae in the family Braconidae. We call the Agathinae the Braconinae and the Braconinae of Marshall, Ashmead and others Vipiinae.

Other curious and unusual cases could be cited and it is practically certain that no set of rules could be made which would, without interpretation and emendation, cover all cases which will arise. There are numerous and difficult questions connected with the application of the rules governing generic names, many of which are not covered by the International Code, and when it is possible to have a method

of choosing supergeneric names which is definite and easily applied I fail to see the advantage of complicating matters by formulating numerous rules which will have to be interpreted or emended.

There has been such a lack of uniformity in forming supergeneric names that the application of any one method throughout Zoology would undoubtedly lead to many changes, and yet for the stability of such names we should make an earnest effort to reach a satisfactory "official" agreement as to methods of procedure. Because of the lack of a policy in the past I think we must digress from our usual method of procedure and adopt definite, although not necessarily the same, methods for all major groups. I believe that the International Commission would do well in appointing committees for all the major groups and that these committees should carefully review the literature of their groups and then recommend to the Commission a policy which would necessitate the fewest changes After the Commission reviewed their report they should submit it, with recommendations, to all contemporary workers in the group. This would permit discussion In the absence of objections an "official" opinion should be rendered Cases where there was objection should be referred back to the committee for consideration and a revised report submitted which would follow the same procedure After all the groups had been covered by opinions these should be formulated into rules and made a part of the Code.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue

CERAMIC CHEMISTRY.—*Note on the mechanics of the weathering of glass.* F. RUSSELL v. BICHOWSKY. Journ. Amer. Ceramic Soc. **3**: 309–312. April, 1920. (Geophysical Lab., Papers on Optical Glass, No. 23*b*.)

The mechanism of the weathering of a glass surface by water is believed to consist of the following stages: (1) true adsorption; (2) diffusion of adsorbed water into the glass, (3) reaction with the silicates; (4) soaking up of more water by the film so produced, (5) extraction of the soluble salts, (6) solution of the silica skeleton. The appearance and behavior on heating of glasses in each of these stages are described. R. B. SOSMAN

CERAMIC CHEMISTRY.—*A practical test of the resistance of optical glass to weathering.* F. RUSSELL v. BICHOWSKY. Journ. Amer. Ceramic Soc. **3**: 296–304. April, 1920. (Geophysical Lab., Papers on Optical Glass, No. 23*a*.)

The experiments described in this paper were made in 1917 with the object of getting a rapid routine method for testing the weather stability of the optical glasses then being made for military purposes. The surface alkali test described by Mylius was used, but its indications are not certain for all types of glasses. Methods of determining the rate of solubility in water, ammonia, or hydrochloric acid were also tried, but were not found adaptable for routine procedures. The tests finally adopted consisted in heating samples of the glass, in company with a standard glass, in water, 5 per cent sodium hydroxide, and 1:1 hydrochloric acid, at temperatures of 175° or 225° C. The glasses could then be classified into 9 groups according to their appearance when wet and when dry, although there is sometimes considerable difference in the order of stability found with the three reagents used. The safest estimate is one based on the three tests taken as a group. R. B. SOSMAN

CERAMICS.—*The manufacture and uses of rolled optical glass.* H. S. ROBERTS and J. C. HOSTETTER. Journ. Amer. Ceramic Soc. **3**: 750–761. Sept., 1920. (Geophysical Lab., Papers on Optical Glass, No. 24.)

Rolled optical glass is manufactured by a process combining the stirring and earlier processes used for ordinary optical glass, with the casting and subsequent processes ordinarily used in the manufacture of rolled plate glass. The glass obtained is characterized by the presence of striae in the form of plane, parallel films, which are in general invisible unless viewed edgewise. Optical systems manufactured from rolled glass should therefore be designed so that the path of light rays cuts the striations in a direction that is as nearly as possible normal to the direction of the striations themselves. The methods of manufacture and inspection are described and a discussion given of the manner of forming the glass into blanks for lenses and prisms. J. C. H.

INORGANIC CHEMISTRY.—*The binary system åkermanite-gehlenite* J. B. FERGUSON and A. F. BUDDINGTON. Amer. Journ Sci IV **50:** 131-140. 1920.

The binary system åkermanite ($2CaO.MgO.2SiO_2$)-gehlenite ($2CaO.Al_2O_3.SiO_2$) was studied by the quenching method and the solidus and liquidus curves determined. The system forms a complete series of solid solutions with a minimum melting point about 70° below the melting point of åkermanite, the component of lower melting point, at a composition of about 74 per cent åkermanite and 26 per cent gehlenite. Åkermanite was found to show the unusual feature of its glass having a greater density than the corresponding crystals at 25° C. The optical characters of the crystals are a continuous function of the composition. Åkermanite is positive in its optical characters and gehlenite is negative. Crystals of certain intermediate compositions are isotropic for light of a definite wave length and constitute a transition phase between positive and negative crystals.

A. F. B.

ORNITHOLOGY.—*Some notes on the plumage of the male Florida Red-wing (Agelaius p. floridanus).* F. C. LINCOLN. Proc. Biol. Soc. Wash. **32:** 196–197. 1919.

A considerable number of non-breeding males of *Agelaius phoeniceus floridanus* were found in Louisiana in June. These birds, though at least a year old, showed clear evidence of immaturity on their obscured or dull-colored orange shoulder patches, and in many cases also in the much less brilliant color of other parts of the plumage, particularly of the black body areas. It would be interesting to know whether this condition is common to all the subspecies of *Agelaius phoeniceus*.

HARRY C. OBERHOLSER.

ORNITHOLOGY.—*The relationships and geographical distribution of the species and races belonging to the genus Rhynchocyclus.* CHARLES B. CORY. Proc. Biol. Soc. Wash. **32:** 217–224. 1919.

A synoptical revision of the tyrannine genus *Rhynchocyclus* results in the recognition of twenty forms, all of which have been hitherto described. Of *Rhynchocyclus sulphurescens*, six forms prove to be valid, of *Rhynchocyclus cinereiceps*, two, of *Rhynchocyclus peruvianus*, two, of *Rhynchocyclus marginatus*, two, of *Rhynchocyclus megacephalus*, one, of *Rhynchocyclus poliocephalus*, three, of *Rhynchocyclus grisescens*, one, and of *Rhynchocyclus flaviventris*, three. Comparison also shows that *Rhynchocyclus sulphurescens pallescens* Hartert and Goodson is a synonym of *Rhynchocyclus sulphurescens* (Spix), and *Rhynchocyclus sulphurescens asemus* Bangs is a subspecies of *Rhynchocyclus cinereiceps* rather than of *Rhynchocyclus sulphurescens*.

HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Descriptions of proposed new birds from Peru, Bolivia, Brazil, and Colombia.* FRANK M. CHAPMAN. Proc. Biol. Soc. Wash. **32:** 253-268. 1919.

Further study of collections of birds from South American has resulted in the discovery of a number of birds new to science. Among these is a new genus of Furnariidae most closely allied to *Automolus* and here named *Hylocryptus*. The following new species and subspecies are also described:

Micropus peruvianus from Ollantaytambo, Peru, *Grallaria watkinsi* from Milagros, Province of Piura, Peru, *Grallaricula boliviana* from Incachaca, Province of Cochabamba, Bolivia, *Synallaxis stictothorax piurae* from Chilaco, near Samate on the Rio Chira, Province of Piura, Peru; *Phacellodomus striaticeps griseipectus* from Tica-Tica, near Cuzco, Peru; *Hylocryptus erythrocephalus* from Alamor, Peruvian-Ecuador boundary; *Xenops rutilus connectens* from Todos Santos, Province of Cochabamba, Bolivia; *Xiphorhynchus triangularis bangsi* from Yungas, Province of Cochabamba, Bolivia; *Thripobrotus layardi madeirae* from Porto Velho, Rio Maderia, Brazil; *Thripobrotus warscewiczi bolivianus* from Incachaca, Province of Cochabamba, Bolivia, *Mecocerculus subtropicalis* from San Miguel Bridge, Urubamba Cañon, Peru, *Anaeretes agraphia* from Idma, near Santa Ana, Peru; *Mionectes striaticollis columbianus* from Santa Elena, Antioquia, Colombia, *Myioborus melanocephalus bolivianus* from Incachaca, Province of Cochabamba, Bolivia, *Basileuterus luteoviridis superciliaris* from above Torontoy, Urubamba Cañon, Peru; *Pheuticus uropygialis terminalis* from San Miguel Bridge, Urubamba Cañon, Peru, and *Catamenia analoides griseiventris* from Cuzco, Peru

HARRY C. OBERHOLSER.

ORNITHOLOGY. -*Mutanda ornithologica. VIII.* HARRY C OBERHOLSER Proc. Biol Soc Wash. **32**: 239–240. 1919.

Recent investigations show that *Pitta atricapilla* Lesson, being antedated by *Turdus sordidus* Müller, must now be called *Pitta sordida* Müller The name of the swallow now known as *Riparia paludicola sinensis* (Jerdan) is preoccupied and must be changed to *Riparia paludicola chinensis* (Gray) For the same reason *Stoporala melanops* (Vigors) must become *Stoporala thassina* (Swainson) Similarly, *Hemipus obscurus* (Horsfield) should stand as *Hemipus hirundinaceus* (Temminck) The South American tanager commonly called *Tachyphonus rufiventris* (Spix) must be rechristened, since its present name is invalidated, and it now may be known as *Tachyphonus metallactus*

H C. O.

ORNITHOLOGY –*An unrecognized subspecies of* Melanerpes erythrocephalus. HARRY C. OBERHOLSER. Canadian Field Nat **33**: 48-50. 1919.

The red-headed woodpeckers inhabiting the Great Plains and Rocky Mountain region of the United States and southern Canada differ from those of the eastern United States in decidedly larger size and usually more reddish posterior lower parts. These differences entitle it to subspecific recognition, and it may be known as *Melanerpes erythrocephalus erythrophthalmus* Silloway

H. C. O.

ORNITHOLOGY – *An all-day bird trip at Washington, D. C.* HARRY C OBERHOLSER. Amer. Midl. Nat. **6**: 103–110 1919.

An all-day trip in the vicinity of Washington, D. C., on May 13, 1907, furnished data on the unusually large number of 103 species and subspecies of birds A few species, such as *Colaptes auratus auratus*, *Penthestes carolinensis carolinensis*, and *Vireo griseus griseus*, were more than ordinarily numerous on this occasion. Two ducks, *Clangula clangula americana* and *Dafila acuta tzitzihoa*, were noted later in the spring than ever before in this region.

H. C. O.

ORNITHOLOGY.—*The migration of North American birds. XI. Canada Jay, Oregon Jay, Clarke's Nutcracker, and Piñon Jay.* HARRY C. OBERHOLSER. Bird Lore 21: 354–355. 1919.

From data chiefly in the United States Biological Survey the geographic distribution and movements of four species of Icteridae have been determined. Five subspecies of *Perisoreus canadensis* are recognized, including the recently described *Perisoreus canadensis sanfordi* and three forms of *Perisoreus obscurus*, including *Perisoreus obscurus rathbuni*. Data on *Nucifraga columbiana* and *Cyanocephalus cyanocephalus* are also given.

H. C. O.

PHYSICAL CHEMISTRY.—*Estimating impurities by means of the melting point curve.* W. P. WHITE. Journ. Phys. Chem. 24: 393–416. 1920.

Freezing points where the thermometer is immersed in the substance are more reliable and precise than those by the capillary tube method. If in addition the form of the freezing curve is observed, there is obtained an indication of the amount of impurity, which is independent of all previous knowledge or uncertainty as to the melting point of the pure substance, and even of the absolute accuracy of the observer's thermometer.

Smallness of dimensions diminishes local temperature differences, and is very often a superior substitute for stirring of the tested substance. It also economizes both time and material. The complications, usually almost negligible, arising from specific heat, uneven temperature, and other causes are considered, and suitable experimental arrangements are suggested.

W. P. W.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

150TH MEETING

The 150th meeting was held in the Assembly Hall of the Cosmos Club on Thursday, November 18, 1920 Dr ELMER D MERRILL, Director of the Bureau of Science, Manila, P I, delivered a popular lecture, *Man and nature in the Philippines*, illustrated by lantern slides

From an ethnological standpoint the Filipino people include three distinct types the primitive negrito, who were undoubtedly the original inhabitants of the archipelago, the proto-Malayan or Indonesian, representing the first invaders, and the Malayan, now numerically and economically the most important element in the native population, comprising the so-called Christian Filipinos and the Mohammedan peoples of Mindanao and the Sulu Archipelago. At the present time more than 40 different languages are spoken in the Archipelago. The language distribution was indicated by a colored lantern slide. Types of many of the different tribes were shown also, and brief notes given regarding them.

In connection with a relief map shown, the essentially mountainous character of the Archipelago was discussed, and some of the more important volcanos were illustrated The three different types of climate (the constantly wet regions, those having alternating wet and dry seasons, and others of an intermediate type) were similarly indicated, and the causes discussed the northeast monsoon, the southwest trades, the typhoons, and the topography. The effects of climate on plant distribution were noted, particularly as delimiting rather strongly the distribution of the major agricultural crops, such as sugar, abaca or manila hemp, coconuts, and tobacco. Types of vegetation were shown and briefly discussed the virgin forest, secondary forests, open grass lands, and settled areas The indications are that the original vegetation was a continuous virgin forest of one type or another, and that primitive man through his destructive methods of clearing land by felling trees and burning, and then after one or two seasons moving on to a new clearing, was largely responsible for the vast areas of open grass lands and second-growth forests now so characteristic of many parts of the Archipelago

Brief notes were given also regarding the extent of the flora and concerning its special relationship, which is distinctly with Celebes and the Moluccas, New Guinea, and northeastern Australia Bornean elements are few and practically fail to reach the Archipelago proper, nor are there any notable special alliances with the Sunda Islands and the Malay Peninsula. The conchology, entomology, ornithology, ichthyology, and general zoology of the Philippines were briefly mentioned, with an indication of the enormous development in species in the first two groups. From a geological standpoint the islands are comparatively recent. This is reflected in the present fauna and flora, the latter in particular being notably rich in endemic species but poor in endemic genera.

In conclusion the speaker gave an interesting account of the Bureau of Science and its work.

151ST MEETING

The 151st meeting was held jointly with the Botanical Society of Washington in the Assembly Hall of the Cosmos Club on Thursday, December 16, 1920. Prof. H. M HALL, of the Carnegie Institution of Washington, delivered an illustrated address, entitled, *Hay fever in its specific botanical relationships*, based upon studies carried out for a number of years in the Rocky Mountain and Pacific coast states in cooperation with certain physicians and specialists, especially Dr. Grant Selfridge, of San Francisco

Hay fever attacks about one per cent of the population of the United States It is not due simply to a local irritation, but to a general poisoning by toxic albumins, derived usually from the pollens of various plants. The conditions of attack are three (1) a defective mucous membrane, permitting the poison to gain access to the circulation, (2) a blood serum lacking in anti bodies; (3) the presence of poisonous pollens in the atmosphere.

A simple nasal operation frequently relieves the first-named condition The second is less accessible to treatment but may be remedied by the injection of solutions prepared from specific pollens The third condition is one to which practically everyone is exposed in the spring, summer, and fall, since pollen is then extremely abundant in the atmosphere. Individuals are more exposed to plant pollens than to any other nitrogenous substance, with the exception of the food in the alimentary tract.

Most plants do not cause hay fever, chiefly for the reason that they do not produce wind-borne pollen. For example, of 1600 species of flowering plants in the District of Columbia perhaps 300 are wind-pollinated About 100 of the latter are grasses. Only about 50 are really abundant, and therefore to be considered first in a "hay fever survey"

Many misconceptions have grown up regarding the sources of hay fever The spring type, often known as "rose cold," has no connection whatever with roses. The common goldenrod is never known to cause hay fever, as it produces very little pollen It does, however, in common with many other plants, carry on its surface considerable quantities of pollens that produce hay fever, such as that of the ragweed Pines produce abundant pollen but do not cause hay fever.

Plants are tested for their capacity to produce hay fever, first, by the botanical method, as above noted, and second, by the injection of a pollen extract into the skin. If the patient is susceptible to poisoning by a given pollen a swelling and reddening are observed around the spot where the extract has been injected.

The principal causes of spring hay fever are grasses, poplars and cottonwoods, oaks, various nut-bearing trees (such as the black walnut, which is a common source in the Sacramento Valley), the cultivated sycamore, the Chenopodiaceae, and the plantains. In the late summer and autumn the principal causes are ragweeds and other members of the ragweed tribe, the artemisias, and some of the Chenopodiaceae

Successful treatment of hay fever depends upon close cooperation between the physician, the botanist, and the laboratory technician. The possible sources of infection in a given district must first be outlined by the botanist Pollen preparations are then made in the laboratory and these are used by the physician in finding out to what pollens the patient is sensitive. Injections of dilute solutions of the specific causative pollens and of no others, increasing from 1 300,000 up to as high as 1. 1,000 or even higher, can then be given before the hay fever season, and produce immunity for at least one

season, and possibly longer It would be entirely feasible to eliminate completely hay fever from the United States, but the rational carrying out of a program toward this end is being seriously jeopardized by the manufacture and sale of various hastily made and ill-selected pollen preparations which are doing a great deal of harm by shaking the confidence of physicians and the public, such nostrums are advertised even in reputable scientific magazines. It is greatly to be desired that reputable and reliable drug manufacturing firms should take up the problem seriously in cooperation with botanists of standing, so that dependable preparations may be made available to physicians.

152D MEETING

The 152d meeting of the Academy, the 23d annual meeting, was held at the Administration Building of the Carnegie Institution of Washington, on Tuesday, January 11, 1921 The meeting was called to order by Vice-President F V COVILLE. Dr J. R JOHNSTON, Chief of the Office of Plant Sanitation, Cuba, and Director of Research for the United Fruit Company, delivered an address on *Some problems in economic biology in tropical America.*

The activities of the Office of Plant Sanitation, Cuba, begun in 1916, were discussed briefly as including plant quarantine, disease and insect control work, and port, railway, and nursery inspection The investigational work is carried out at the Estacion Experimental, Santiago de las Vegas. Instruction is given in a recently instituted course of plant pathology in the University of Havana The presence of a considerable force of field inspectors throughout the island gives excellent opportunities for discovering new pests and diseases, new facts about them, and new investigational data regarding the old ones

Special attention is being given to coconut budrot, control of the citrus black fly, and to investigation and control of the sugar cane mosaic disease.

The several types of budrot and their bacterial and fungoid origin were discussed at length Although progress is being made in combating disease, losses caused by it in the American tropics as a whole are enormous At the present time spraying, cutting down and burning infected trees, and replanting are the most practical methods of control. Progress might conceivably be made by introduction of the disease-resistant varieties, a course which is being undertaken in Panama

The coconut suffers also from the "red ring" disease, characterized by a dark red ring seen in the trunk in cross-section. The discolored tissues are found to be full of nematodes. This disease, first described from Trinidad and Grenada, is known also from Cuba and Central America, and is apparently widespread It is especially destructive in Trinidad, but neither here nor elsewhere has any satisfactory method of control been worked out Plantations on hilly regions are apparently free from this disease, which is found in its most acute form in drained lowlands.

Hardly second in destructiveness to any other known plant disease is the so-called "banana wilt," caused by *Fusarium cubense.* This is widespread in tropical America and occurs in many regions of the Old World also. Sanitary measures have almost no appreciable effect, and the disease has progressed rapidly and caused enormous losses. Certain varieties of bananas are highly resistant. The propagation of these seems to offer the most likely solution.

The mosaic disease of sugar cane and the control of the citrus black fly were discussed, the difficulties of the latter work being especially emphasized.

Many organizations are carrying out elaborate investigations of cane varieties, and deep regret was expressed by the speaker that similar work was not being conducted on a large scale in the case of the coconut and banana, since these two crops afford the most important pathological problems of economic botany in all tropical America Considering the huge investments of American capital and the large part tropical foodstuffs play in our national food supply, the speaker deprecated strongly the lack of vital interest in the problems of the tropics and the disinclination of many American scientists to undertake investigations in this interesting and all-important field of work

Following the address a business meeting was held The Corresponding Secretary, ROBERT B. SOSMAN, reported that the membership remained at 541, consisting of 6 honorary members, 3 patrons, and 532 members, one of whom is a life member. Of this number, 330 reside in or near the District of Columbia. Twenty-two resignations were accepted during the year, 16 of these being of non-resident members The members who died during the year are: JOHN ALFRED BRASHEAR, ALBERT HUGH BRYAN, ROBERT HOLLISTER CHAPMAN, ARTHUR J ELLIS, WALTER FAXON, WILLIAM CRAWFORD GORGAS, HENNEN JENNINGS, HARMON NORTHROP MORSE, CEPHAS HEMPSTONE SINCLAIR.

The Corresponding Secretary reported also on the activities of the Academy during 1920. These were largely centered in the continued publication of the *Journal*, but included assistance in several other projects of practical value, such as the classification of the scientific and technical employees in the Federal service, as well as matters of local educational interest

The Recording Secretary, WILLIAM R MAXON, reported briefly upon the thirteen public meetings held during the year, at which illustrated lectures were delivered. These covered a wide range of subjects and were well attended.

The report of the Treasurer, R L FARIS, showed total receipts of \$5,829 73 and total disbursements of \$5,515 38, the cash balance on hand being \$1,792.62 The investments of the Academy have a total par value of \$15,030 37. The cost of printing the *Journal* in 1920 was \$2,873.74 as against \$2,550 for 1919. A further increase in unavoidable in 1921.

The report of the Auditing Committee, consisting of E. D WILLIAMSON, B. L. JOHNSON and H. C. OBERHOLSER, was read, and the reports of the Treasurer and Auditing Committee were accepted

The report of the Editors of the Journal was read by J FRANKLIN MEYER, the senior editor.

The committee of tellers, consisting of N L. BOWEN, W. F. MEGGERS and R B. SOSMAN, reported that the following officers had been elected for 1921 *President*, ALFRED H. BROOKS; *Corresponding Secretary*, ROBERT B. SOSMAN, *Recording Secretary*, WILLIAM R MAXON, *Treasurer*, R. L. FARIS, *Non-resident Vice-Presidents*, J. MCKEEN CATTELL, E. B. WILSON, *Members of Board of Managers, Class of 1924*, H. S. GRAVES, SIDNEY PAIGE.

The following *Vice-Presidents* nominated by the affiliated Societies were then elected *Archaeological Society*, ALES HRDLICKA, *Biological Society*, NED HOLLISTER, *Botanical Society*, A S. HITCHCOCK, *Chemical Society*, WILLIAM BLUM, *Institute of Electrical Engineers*, F B. SILSBEE, *Society of Engineers*, R. L. FARIS, *Entomological Society*, S. A. ROHWER, *Society of Foresters*, RAPHAEL ZON, *National Geographic Society*, FREDERICK V COVILLE, *Geological Society*, DAVID WHITE, *Historical Society*, ALLEN C CLARK, *Philosophical Society*, W. J. HUMPHREYS.

WILLIAM R MAXON, *Recording Secretary*

BOTANICAL SOCIETY

145TH MEETING

The 145th regular meeting of the Botanical Society of Washington was held at the Cosmos Club, 8 p m , October 5, 1920. Thirty-three members and one guest were present.

Mr. ALBERT A HANSEN gave an illustrated talk on *Our disappearing wild plants.* He explained that although the transition which our flora is undergoing is attributable to some extent to such unavoidable causes as lumbering, building, the cultivation of new land and grazing, the greatest damage is due to avoidable causes, such as the promiscuous gathering of wild flowers by thoughtless pickers and the commercial exploitation of the wild flora He also referred to the educational methods used by the Wild Flower Preservation Society of America to create a strong sentiment in favor of protecting our handsome wild plants Among the plants needing protection are columbine, arbutus, pitcher plants, ground pine, flowering dogwood, rhododendron, and several lilies and orchids

20TH ANNUAL MEETING

The 20th annual meeting of the Botanical Society of Washington was held at the Cosmos Club, October 5, 1920. The following officers were elected for the ensuing year President, CHAS E CHAMBLISS, Vice-President, P L. RICKER, Recording Secretary, ROY G. PIERCE, Corresponding Secretary, R KENT BEATTIE, Treasurer, L L HARTER Prof A S HITCHCOCK was nominated for Vice-President in the Washington Academy of Sciences

CHARLES E CHAMBLISS, *Recording Secretary*

146TH MEETING

The 146th meeting of the Society was held at the Cosmos Club on November 2, 1920, 62 members and guests being present, and the President, Mr CHARLES E CHAMBLISS, in the chair

Under *Brief Notes* Dr A S HITCHCOCK spoke of the valuable collection of South American grasses just received by the National Herbarium from Germany. The program was as follows

W E SAFFORD *The first Pan-Pacific Scientific Conference* (illustrated)

This conference, at which Dr Safford was a delegate from the U S Department of Agriculture, was held at Honolulu, August 2 to August 20, 1920 Delegates were present from the United States, British Columbia, Hawaii, New Zealand, Australia, New South Wales, the Philippine Islands, and Japan

The scope of the topics discussed was very wide, embracing a discussion of most of the physical and biological phenomena of the Pacific. The sessions of the Conference were interrupted by a visit to the active volcano of Kilauea and an excursion around the west coast of the island of Hawaii

As a result of the conference, a number of resolutions were presented by the various sections, among them the following

That any agency created for the guidance of scientific research and exploration in the Pacific region should be affiliated with the International Research Council, that the attention of Governments be invited to the desirability of providing vessels for suitably planned expeditions of scientific research, similar in character to the Wilkes and the Challenger expeditions, that young men and women should be trained for scientific work and that such work be adequately compensated Other resolutions bore upon the

desirability of studying the anthropology of Pacific races, the making of a magnetic, geographical, physical and biological survey of the Pacific Ocean, including a study of bottom samples, brachiopod faunas as an index to former land connections, algae, ecology of corals on coral reefs, land faunas of Pacific islands, and the relation of living forms to extinct allied forms, Pacific birds, land flora including problems of forestry, agriculture, ethnobotany, plant ecology on oceanic islands and on new lava flows and ash deposits from volcanic ejections, the preservation of the Hillebrand garden at Honolulu, also the establishment of a meteorological station on Mauna Loa, the study of volcano and earthquake phenomena, and the publication of information relating to them, and the continuation of the geophysical observatory at Samoa

SAMUEL B DETWILER *White pine and the blister rust* (illustrated with motion pictures and accompanied by specimens)

The white pine is probably the best known timber tree in the country, and up to 1880 produced the bulk of the country's lumber cut In the East most of the white pine had been removed by 1890, and the present lumber cut in New York, Pennsylvania, Michigan and Wisconsin is only a small fraction of what it was formerly In New England, however, because of the ability of this species to restock abandoned lands, the white pine has held its own

The blister rust infection is heaviest in New England and eastern New York This disease, as far as is known, has not crossed the Great Plains and infected the very valuable sugar pine and western white pine forests While there are federal and state quarantines, prohibiting the shipment of five-leaf pines and Ribes (currants and gooseberries) from the East to the West, yet there have been numerous violations of these quarantines, any one of which, had it not been caught, might have carried the blister rust to the western forests The Dominion of Canada is cooperating with the United States in trying to protect the West and has adopted quarantines similar to ours These quarantine measures will, however, break down unless adequate inspection is made to prevent violations That our western white pines are subject to infection from blister rust is borne out by recent letters from Mr WM. S. MOIR who is studying the blister rust in Europe for the United States Department of Agriculture He has found not only the eastern white pine heavily infected, but also the limber pine, sugar pine and western white pine

The blister rust infection on white pine in the East is increasing rapidly A strip survey in New Hampshire showed 26 per cent of the pines infected on an area of 72 square miles A similar strip, studied in New York, showed 10 per cent of the pines infected

Protective measures in the East consist of the destruction of the alternate hosts of the blister rust, currants and gooseberries, both wild and cultivated In 1919, over 250,000 acres were cleared of Ribes in the North East The average labor cost per acre in New England was 24 cents, in New England and New York, 42 cents, and with supervision 54 cents Experience has shown that the Ribes eradication crews destroyed over 95 per cent of the bushes in one working, and that the leaf surface destroyed is over 99 per cent Chemical eradication of Ribes is being tried out and has proven quite successful. An ecological study of currants and gooseberries, which is being carried on, is expected to further reduce the cost of eradication

147TH MEETING

The 147th meeting was held in the Assembly Hall of the Cosmos Club, December 7, 1920, with 56 members and 10 guests present, and President

CHAMBLISS in the chair. JAMES M. R. ADAMS, SAMUEL B. DETWILER, HARRY T. EDWARDS, PETER KLAPHAAK, and FREDERICK D. RICHEY were elected into the Society. The names of WM. DIEHL, Dr. J. F. MARTIN, Dr. EBEN H. TOOLE and Mr. FREEMAN WEISS were presented as candidates for membership.

Under *Brief notes and reviews of literature*, Dr. HAVEN METCALF presented two books as worthy of the study of any scientist. The first is by Émile Duclaux, entitled *Pasteur, Histoire d'un Esprit*, and published in 1896. This book has been translated into English by Dr. ERWIN F. SMITH and Miss FLORENCE HEDGES under the title of *Pasteur, History of a Mind* (published by the W. B. Saunders Co., in 1920). Dr. E. D. MERRILL called attention to two of his publications which were little known, one entitled *A Commentary on Loureiro's Flora Cochinchinensis*, in 2 volumes, typewritten in 1919. But 5 copies were issued, one of which is in the Library of the U. S. Department of Agriculture. The second, *Species Blancoanae*, a critical revision of the Philippine species of plants described by Blanco and Danos, was put out in Manila in typewritten form in 1917. This work is also in the Library of the U. S. Department of Agriculture.

Regular Program

E. D. MERRILL. *Vegetation of the Philippines* (illustrated by lantern slides).

The salient features of the Philippine flora were discussed, and so far as possible the points were illustrated. The known flora comprises about 8500 species of phanerogams and nearly 1000 species of ferns and fern allies, while, excepting the algae, the various groups of cellular cryptogams are relatively highly developed. The percentage of specific endemism is high, over 60 per cent, while generic endemism is very small, indicating a separation from other parts of Malaya sufficiently long to allow the development of very numerous local species, but not long enough to permit the development of many genera. The Archipelago presents Asiatic, Malayan, Australian, and Polynesian elements, but its flora is essentially Malayan. The continental elements are practically confined to the mountains of northern Luzon, the Polynesian and rather striking Australian elements are nowhere dominant, but occur at both low and high altitudes. While the Philippine flora is essentially Malayan, there are practically no special alliances with Borneo, Sumatra, Java, and the Malay Peninsula, but there are very striking special alliances with the islands to the south and southeast, Celebes, the Moluccas, New Guinea, tropical Australia, and New Caledonia. The indications are that the original Philippine flora came largely from the islands to the south and southeast, not from the Sunda Islands to the southwest. It would seem probably that an ancient continent extended from the Philippines to the south and southeast at least as far as New Guinea, and that the plant migration followed what may have been a coastal plain region to what is now the Philippine Archipelago.

The various types of vegetation in the Philippines were discussed in detail, the virgin forest, secondary forest, and open grass lands. It was assumed that the original vegetation was a virgin forest of one type or another, and that the secondary forests and open grass lands, as well as the cultivated areas, are due to the activities of man. A cleared area once deserted almost never reverts to primary forest, but to open grass lands, bamboo thickets or secondary forests. Specific endemism in primary forests runs as high as 70 per cent, while in secondary forests, open grass lands, and settled areas it is

but about 7 per cent. It would seem that very many of the species of wide geographic distribution now characteristic of regions outside of the virgin forest, had been introduced into the Archipelago by one means or another, after the activities of man in the Archipelago had prepared regions suitable to their growth.

This paper was briefly discussed by several members.

The program was followed by a social hour with refreshments.

A joint meeting was held with the Washington Academy of Sciences on December 11, at which Dr. H. M. HALL of the Carnegie Institute spoke on *Hay fever and its specific botanical relationships*.

148TH MEETING

The 148th meeting was held in the Assembly Hall of the Cosmos Club on January 4, 1921, with 50 members and 7 guests present, and President CHAMBLISS in the chair. The minutes of the last meeting were read and approved Mr. WILLIAM W. DIEHL, Dr. JAMES F MARTIN, Dr. EBEN H. TOOLE, and Mr. FREEMAN WEISS, all of the Bureau of Plant Industry, were elected to membership. The executive committee presented the name of Mr JOSEPH W. WELLINGTON as candidate for membership President CHAMBLISS announced the meeting of the Washington Academy of Sciences on January 11, to which the members of the Botanical Society were cordially invited

Brief reports were made by Dr A S HITCHCOCK, Prof C V PIPER, and Dr W. H WESTON on the Chicago meetings of the Association for the Advancement of Science, with particular reference to systematic botany, agronomy and pathology.

F. LAMSON-SCRIBNER *The lure of Rock Creek Park* (illustrated by lantern slides)

Rock Creek Park in the District of Columbia, embracing over 1600 acres and extending for between 4 and 5 miles along both sides of Rock Creek, is wild and interesting Much of it is unchanged from pre-Colonial days Since picking flowers and plants is prohibited in the park, it is a real plant preserve, and a pleasure to all lovers of wild flowers About 800, or one half of the species of flowering plants and ferns listed in the latest "Flora of the District and Vicinity," may be found within the park.

At one point in the creek bottom are large boulders that show remarkable pot holes, worn in the rocks by the action of water centuries ago In the, cool shaded ravines are found the maidenhair fern, with jack-in-the-pulpit, false solomon seal and bellwort, where the soil is rich and the trees less dense, the black snakeroot and *Astilbe* or false goats beard occur One of the very first flowers in the spring is the hepatica

Farther north we pass Joaquin Miller's picturesque log cabin. This cabin was formerly located at 16th Street above Florida Avenue and was moved to its present site in 1911. A number of fine springs are located in the park, which offer deliciously cool water to those who know where to find them.

The Park that presents so many, so varied and so beautiful and natural attractions in the summer season, offers hardly less beautiful scenes when the winter snows are on the ground and the trees and shrubs are festooned with crystal whiteness.

The paper was discussed by Dr PAUL BARTSCH.

J. MARION SHULL: *Skunk cabbage*, Spathyema foetida (with lantern). The skunk cabbage pursues for an indefinite number of years a monopodial juvenile existence until such time as the terminal bud becomes modified to

produce the first inflorescence, after which the growth becomes sympodial and so continues to a possible extreme and indefinite old age. The sympodial stage is characterized by a succession shoot of but two leaves. In the axil of the first of these leaves a bud lies dormant and is rarely permitted to develop further. The terminal bud being converted into an inflorescence, it thus devolves upon the second axillary bud to produce the new terminal and in its turn bear its leaves and surmounting spathe. Barring accident this succession continues ad infinitum The leaf arrangement, which has always been in question, is difficult to trace, but elongated growths appear from deep seated lateral buds showing a close approximation to the familiar 2/5 cycle.

Balance between photosynthesis and fruit production is maintained by the regular suppression of most of the inflorescence, this abortion being apparently brought about through strangulation due to growth pressure of the leaf bases

Contrary to popular opinion the spathe is not of rapid development, dissections showing that it is differentiated as much as twenty-seven months in advance of anthesis. There is no means of determining the age of an individual skunk cabbage, and there is no apparent reason why this plant may not outlive the oldest of the oaks

R G PIERCE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

To aid in the rehabilitation of the library of the Department of Botany, Alabama Polytechnic Institute, Auburn, Alabama, which was destroyed by fire on October 17, 1920, the Smithsonian Institution, at the request of Prof WRIGHT A GARDNER, has undertaken to receive and forward to the Institute such publications as botanists and others in the vicinity of Washington may desire to present for that purpose All packages should be plainly marked "Library, Department of Botany, Alabama Polytechnic Institute, Auburn, Alabama," and delivered to the Smithsonian Institution, charges paid

The Washington Chapter of the American Association of Engineers has begun the publication of a monthly news organ under the title of *The Washington Engineer* A. D MOREHOUSE is editor and THOMAS H FARIS associate editor of the new publication

The Division of Graphic Arts of the National Museum has just received from the American Museum of Natural History in New York fifty specimens of metal movable type made from the fifty original bronze type which were cast in Seoul, Korea, about 1400, and were owned by the Government Printing Office There seems to be little doubt that the credit for making the first movable metal type belongs to Korea, as Gutenberg did not start his press in Europe until about fifty years later There was a movable clay type in China about two hundred years earlier

The Pick and Hammer Club met on Saturday, January 29, at the Geological Survey Talks were given by F H MOFFIT on *Some of the features of the problem of making maps from aeroplane photographs*, H B SULLIVAN, on *Some difficulties attending the practical application of aerial photography to mapping, from the viewpoint of the pilot of the observation plane*, and W T LEE, on *A look forward—the use of aeroplane photography in geology*

The Section of Vertebrate Paleontology of the National Museum has received as a gift from the Southern Coal, Coke and Mining Company of Shiloh, Illinois, a beautifully preserved specimen of the extinct Carboniferous shark *Edestus heinrichsi* It was found by one of the miners

The Bureau of Standards announces a new method for producing very small and light mirrors for use on oscillographs and similar apparatus These mirrors can be made in dimensions as small as 1 5 by 0 5 by 0 1 mm, and of satisfactory planeness and polish, by compressing aluminum between optically flat steel dies.

Mr. J W. GIDLEY, Assistant Curator of Vertebrate Paleontology at the National Museum, left Washington in January for a two months' exploratory trip in Arizona, California, and Nebraska for the U S Geological Survey and to secure fossil mammals for the Museum collection Important finds of Pleistocene mammal remains in the vicinity of Benson, Arizona, have already been made.

Mr. GEORGE L. HARRINGTON recently returned from South America, where he had been engaged for ten months in private work, and resumed work in the Alaskan Division of the U. S. Geological Survey. He went back to South America early in February

Mr. HERBERT INSLEY has been transferred from the U. S. Geological Survey to the Bureau of Mines as petrographer He will conduct petrographic studies of dust in metal mines and related petrographic problems at the experiment station of the Bureau at Pittsburgh.

Mr. EDWIN KIRK, who resigned from the U. S. Geological Survey in April, 1920, to do private work in South America, has been reinstated as geologist with the Survey

Mr J C MARTIN has resigned his position in the Foreign Mineral Section of the U. S. Geological Survey, and will go into private work in oil geology.

Mr HOMER F STALEY, metallurgical ceramist at the Bureau of Standards, resigned in December to become ceramic engineer with the Metal and Thermit Corporation, 120 Broadway, New York City

Mr. EUGENE STEBINGER, formerly in charge of the Foreign Mineral Section of the U. S. Geological Survey, has resigned to engage in private work.

Dr. F. A. WOLFF of the Bureau of Standards gave a lecture before the City Club on January 26 on *A scientific analysis of Federal expenditures.*

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BOTANY.—*The American species of Maximilianea (Cochlospermum).*
S. F. BLAKE, Bureau of Plant Industry.[1]

The principal genus of the small family Cochlospermaceae is that which has generally been known under the name *Cochlospermum*, given it by Kunth in 1822. Three years previously Schrank had published for another species of the same genus Martius' manuscript name *Maximilianea*, and it is this name which must be employed for the genus under the American Rules. Martius' single species was named *Maximilianea regia* in honor of King Maximilian of Bavaria. Unfortunately, Martius was not satisfied with this dedication and employed[2] the same name (in the spelling *Maximiliana*) a few years later for a species representing a new genus of palms, for which it has generally been adopted. Simultaneously he proposed the name *Wittelsbachia* for the genus which he had earlier called *Maximilianea*, Kunth's name *Cochlospermum* being rejected because of the prior *Cochliospermum* of Lagasca.

In 1847 Planchon published a revision of the family Cochlospermeae. He[3] divided the genus *Cochlospermum* into two subgenera: *Eucochlospermum*, including as American species *Cochlospermum insigne* and *C. hibiscoides*, and *Diporandra*, containing three species, all American, two of which were described as new. The first subgenus was characterized by its strongly imbricated sepals, free filaments, anthers opening by a single apical pore, reniform seeds, and palmatifid leaves, the second by its slightly imbricated sepals, irregularly subconnate filaments, two-pored anthers, twisted seeds (?), and digitate leaves. This classification was followed in Eichler's treatment in the *Flora Brasiliensis*.

[1] Received January 15, 1921.
[2] Hist. Nat. Palm. 2: 131. 1824.
[3] Lond. Journ. Bot. 6: 306–311. 1847.

In a collection recently made by Mr. Henri Pittier in Venezuela is a new species of this genus, which combines to some extent the characters relied upon by Planchon and Eichler for the separation of their subgenera. The leaves are digitately trifoliolate, but the anthers open by a single terminal pore and two tiny basal pores. Another species, described from Bolivia by H. Hallier, has digitate leaves and anthers opening by two apical pores and two smaller basal pores. Hallier raised the question whether these basal pores may not have been overlooked in other species of the subgenus *Diporandra*, but was prevented by lack of material from determining this point. There are in the National Herbarium no flowers of any of the previously described species of this subgenus, so that the question remains an open one, but it is probable, from the fact that two minute lateral basal pores are found in the anthers of *M. vitifolia*, of the group *Eucochlospermum*, that they occur in all the species.

The species of *Maximilianea* are shrubs or trees, with alternate palmatifid or digitate leaves and short panicles of handsome yellow flowers. The inner bark of two species (*M. regia* and *M. vitifolia*) is used in Brazil and Mexico for making ropes and cord, and the latter species (*M. vitifolia*) is sometimes grown as a hedge plant in the American tropics, but in general the genus is of little economic importance.

Maximilianea Mart., Schrank, Flora **2**: 451. 1819.

Cochlospermum Kunth, Malv. 6, footnote[4] 1822, H. B. K. Nov. Gen. & Sp. **5**: 297, footnote. 1822.
Wittelsbachia Mart. & Zucc. Nov. Gen. & Sp. **1**: 80. *pl. 55*. 1824.
"*Azeredia* Arruda, Allem. Appar. Coll. Desenh. Arruda, *cum tab.* 1846."
Type species *M. regia* Mart. & Schrank.

KEY TO SPECIES

Leaves palmate-lobed, the lobes serrate.
  Leaves 7-lobed, the lobes lanceolate, subcaudate-acuminate. 1. *M. codinae*.
  Leaves 3- to 7-lobed, the lobes obovate to oblong, acuminate to obtusish.
    Shrub 2 meters high; leaves 10 to 12 cm. wide, capsule glabrate, obtuse. 2. *M. regia*.
    Tree up to 8 meters high or more, leaves 10 to 33 cm. wide, capsule densely griseous-tomentellous, umbilicate. 3. *M. vitifolia*.
Leaves digitately 3- to 7-foliolate, the leaflets entire.
  Leaflets 3, anthers with a single terminal pore. 4. *M. triphylla*.
  Leaflets 5 to 7 (rarely 3); anthers with 2 terminal pores.
    Middle leaflet 10 to 18 cm. long.
      Middle leaflet 2 cm. wide, capsule glabrous, about 25 mm. long. 5. *M. tetrapora*.

[4] Genus named and one species (*Bombax gossypium* L.) cited, but no description or diagnosis.

Middle leaflet 3 to 6.5 cm. wide, capsule densely puberulous, 6 to 7.5 cm. long. 6. *M. orinocensis.*

Middle leaflet 5 to 7.5 cm. long.

Leaflets very obtuse, long-attenuate at base. 7. *M. parkeri.*

Leaflets abruptly acuminate, sessile. 8. *M. pavinaefolia.*

1. **Maximilianea codinae** (Eichl.) Kuntze, Rev. Gen Pl. **1**: 44, as *Maximiliana.* 1891.

Cochlospermum codinae Eichl. in Mart. Fl. Bras. **13**[1]: 431. *pl 86, f 1.* 1871.

Leaves 7-lobed, the lobes lanceolate, subcaudate-acuminate, glaucescent beneath, two outer sepals oblong-ovate, subacute, the three inner rounded, petals three times as long, capsule obovate-oval in outline, obtusely 5-angled, 5-valved.

TYPE LOCALITY Banks of the Río Pará, Brazil

Described by Eichler from a drawing by Codina.

2. **Maximilianea regia** Mart & Schrank, Flora **2**: 452. 1819.

Wittelsbachia insignis Mart & Zucc Nov. Gen & Sp **1**: 81. *pl 55.* 1824.

Bombax hibiscifolium Willd., Mart & Zucc Nov. Gen & Sp. **1**: 81, as synonym.[5] 1824.

Cochlospermum insigne St. Hil. Pl. Us Bras *pl. 57.* 1827.

"*Azeredia pernambucana* Arruda; Allem. Appar Coll Desenh Arruda, *cum tab.* 1846."

Cochlospermum insigne var. *pohliana* Eichl. in Mart. Fl Bras **13**[1]: 430. 1871.

Shrub about 2 meters high, branchlets pubescent at apex; petioles puberulous, 8 to 14 cm. long, leaves about 10 to 12 cm. wide, 3- or 5-lobed for three-fourths their length, the lobes oboval or ovate-oblong, acuminate to obtusish, pubescent beneath at maturity, the middle lobe 8 to 12 cm long, 4 to 5 cm wide, panicle pyramidate, the lower branches 2- to 4-flowered, the upper 1-flowered, pedicels 1.5 to 2.5 cm. long, tomentellous; flowers 6 to 8 cm wide, two outer sepals ovate or oblong, subacute or obtuse, puberulous, the three inner 16 to 20 mm. long, 12 to 14 mm. broad, less pubescent, petals subquadrate-obovate, usually emarginate, stamens free, the anthers dehiscent by an apical pore; ovary with 3 to 5 placentae, capsule 3- to 5-valved, oblong-pyramidal, obtuse, 7 cm. long, glabrate; seeds reniform, 6 to 7 mm. wide, involved in dense whitish wool.

TYPE LOCALITY Eastern Brazil.

RANGE: Provinces of Pernambuco, Goyaz, Bahia, and Minas Geraes, Brazil.

Not seen; the description compiled from those of Martius and Zuccarini and St. Hilaire, and from Eichler's[6] account in the *Flora Brasiliensis* The capsule is said to have the odor of dill (*Anethum graveolens*). The filamentous bark, according to Eichler, is used for making rope. St. Hilaire states that a decoction of the roots is used for internal troubles, principally those resulting from falls or other accidents, and that this decoction is said to heal abscesses. He gives the native name as "butua do curvo"

[5] Wrongly referred to this species, according to Eichler

[6] Fl Bras. 13[1]: 429–431 *pl 86, f. 2* 1871.

The typical form has the leaves somewhat pubescent beneath. The form described as var *pohliana* by Eichler, with slightly larger and thicker always 3-lobed leaves, seems unworthy of recognition Two other varieties, which appear sufficiently distinct for recognition by name, are the following·

Maximilianea regia glaberrima Chod. & Hassl. Bull. Herb. Boiss II **3**: 810. 1903.

Leaves strictly glabrous.

Described from *Hassler* 4934, from Nunduruccay, and 4392, from the Río Capibary, Paraguay Said to be a shrub 30 to 40 cm. high

Maximilianea regia mattogrossensis (Pilger) Blake.

Cochlospermum insigne var. *mattogrossensis* Pilger, Bot Jahrb Engler **30**: 176. 1901.

Leaves densely and shortly cinereous-tomentose beneath

Described from *Pilger* 518, from the upper Cuyabá Valley, Matto Grosso. Said to be a shrub with several unbranched stems from a thick rootstock.

3 **Maximilianea vitifolia** (Willd) Krug & Urb Bot Jahrb. Engler **15**: 293, as *Maximiliania*. 1892

Bombax vitifolium Willd. Enum. Hort Berol. **2**: 720. 1809

Cochlospermum serratifolium DC Prodr **1**: 527. 1824

Bombax serratifolium [Moc. & Sessé,] DC. Prodr. **1**: 527, as synonym 1824.

Mahurea ? *speciosa* Choisy in DC Prodr **1**: 558 1824

Wittelsbachia vitifolia Mart & Zucc Nov Gen & Sp **1**: 82 1824.

Cochlospermum hibiscoides Kunth, Syn Pl Aequin **3**: 214 1824.

Cochlospermum vitifolium Willd , Spreng Syst **2**: 596, in part. 1825, Syst **4**: Cur Post 206 1827

Maximiliana hibiscoides Kuntze, Rev. Gen Pl **1**: 44. 1891

Large or small tree, branchlets at first loosely pilose, petioles more or less pubescent, glabrate, 8 to 28 cm long, leaves usually 5-lobed, rarely 3- or 7-lobed, for one-half to three-fourths their length, 10 to 33 cm wide, above more or less puberulous along the impressed veins, beneath loosely pilose along the veins and in youth along the chief veinlets, the lobes oblong to oval or obovate-oval, short-pointed or abruptly short-acuminate, inflorescence sordid-pubescent, the axis 3 to 9 cm long, the spreading or ascending branches several-flowered toward the tip, pedicels densely puberulous or tomentulose, 2 to 3 cm. long, flowers 7.5 to 12 5 cm wide, two outer sepals ovate to oblong-ovate, obtuse to rounded, sparsely or densely puberulous, 10 to 12 mm. long, the three inner broadly oval, rounded, finely and densely cinereous-puberulous, 16 to 22 mm long, stamens free, the anthers opening by an apical pore and 2 minute basal pores, capsule broadly obovate-oval, 7 to 8 cm long, about 6 cm. thick, densely griseous-tomentellous, 5-valved, umbilicate at apex, seeds involute-reniform, 4 5 mm. wide, involved in long whitish wool

ILLUSTRATION Hemsl. Biol Centr. Amer. Bot *pl. 2*.

TYPE LOCALITY "Brazil" (*i e.*, Campeche, *fide* Mart & Zucc)[7]

RANGE Western Mexico, from Sinaloa and Guerrero to Chiapas and Yucatan, southward to Colombia (Santa Marta, *H. H Smith* 830), and reported from Venezuela and Guayaquil,[8] also Cuba (introduced).

The species bears the following local names, many of which have been furnished me by Mr Paul C Standley "rosa amarilla" (Sinaloa, where the

[7] MART & ZUCC Nov Gen & Sp **1**: 82 1824

[8] H B K Nov Gen & Sp **7**: 223 1825

orange inner bark is used for making ropes); "palo amarillo," "palo de rosa amarilla" (Durango); "panaco" (Acapulco, Guerrero); "madera de pasta" (Veracruz, *Ramírez*); "apompo," "pongolote," "cojón de toro" (Oaxaca); "pochote" (Tabasco, Oaxaca); "cocito" (Chiapas); "tecomasúchil" (Chiapas, Guatemala); "quie-riga," "quie-quega," "huarumbo," "flor izquierda" (Chiapas and Oaxaca, *Seler*); "chuun," "chum," "chimu" (Maya, Yucatan), "tecomaxochitl" (Nahuatl); "tecomasuche" (Guatemala); "bombón," "catamericuche" (Nicaragua); "poró-poró" (Nicaragua, Panama, Costa Rica, Colombia); "flechero," "batabana," "bototo" (Venezuela, Colombia), "botija" (Cuba). Kunth[9] mentions the local names "botulo" (Guayaquil) and "carnestolendas" (Aragua, Venezuela). The branches root readily if thrust into the ground, and are frequently used to form hedges.

The original description of this species is so brief that it would not suffice to distinguish between *M. regia* and *M. vitifolia* as generally adopted. Willdenow gives the locality as Brazil, but Martius and Zuccarini, who examined the original in the Willdenow Herbarium, accredit it to Campeche, and their statement is here taken as authority for the use of the name in its generally accepted sense. *Mahurea ? speciosa*, which was based by Choisy on a single flower collected at Santa Marta by Bertero, is considered by St. Hilaire, who examined the original, as scarcely distinct from *M. regia*. It is clear, however, from the good specimen collected at the same locality by Herbert H. Smith, that the name belongs rather to *M. vitifolia*.

The ovary of *Cochlospermum hibiscoides* was wrongly described by Kunth as glabrous.

4. **Maximilianea triphylla** Blake, sp. nov.

Small tree, branchlets glabrous, lenticellate, petioles glabrous, 12.5 to 16 cm. long; leaflets 3, on petiolules 1 to 2 mm. long, the blades nearly membranaceous, the terminal one obovate-oval, 14.5 cm. long, 7.8 cm. wide, short-pointed with obtuse apex, broadly cuneate at base, glabrous, entire, marginate, light green, the chief nerves about six pairs, curved, ascending at an angle of about 60°, the secondary veins somewhat prominulous; lateral leaflets similar, oval, inequilateral, 12.5 cm. long, 6 cm. wide; flowering axis 6 cm. long, with about 5 short horizontal branches, sordid-puberulous toward the tip, each bearing toward apex about 4 flowers; pedicels obscurely puberulous, 2.8 cm. long, sepals 5, the two outer elliptic-oblong, rounded, sordid-pilose, dark colored, about 1.7 cm. long, 6 mm. wide, the three inner suborbicular, broadly rounded, densely canescent-pilosulous, 2 cm. long, petals 5, cuneate-obovate, apparently emarginate at apex, bright yellow, 5 cm. long, 2 to 2.5 cm. wide; stamens very numerous, with free glabrous filaments, the anthers yellow, linear, 4.8 to 6 mm. long, dehiscing by a single terminal pore and two minute basal pores; ovary densely tomentose, 5-celled; style glabrous, 3.5 cm. long.

Type in the U. S. National Herbarium, no. 1,065,095, collected in hedges at Valencia, Venezuela, April (flowers) and July (leaves), 1920, by H. Pittier (no. 8930).

[9] H. B. K. Nov. Gen. and Sp. 7: 223. 1825.

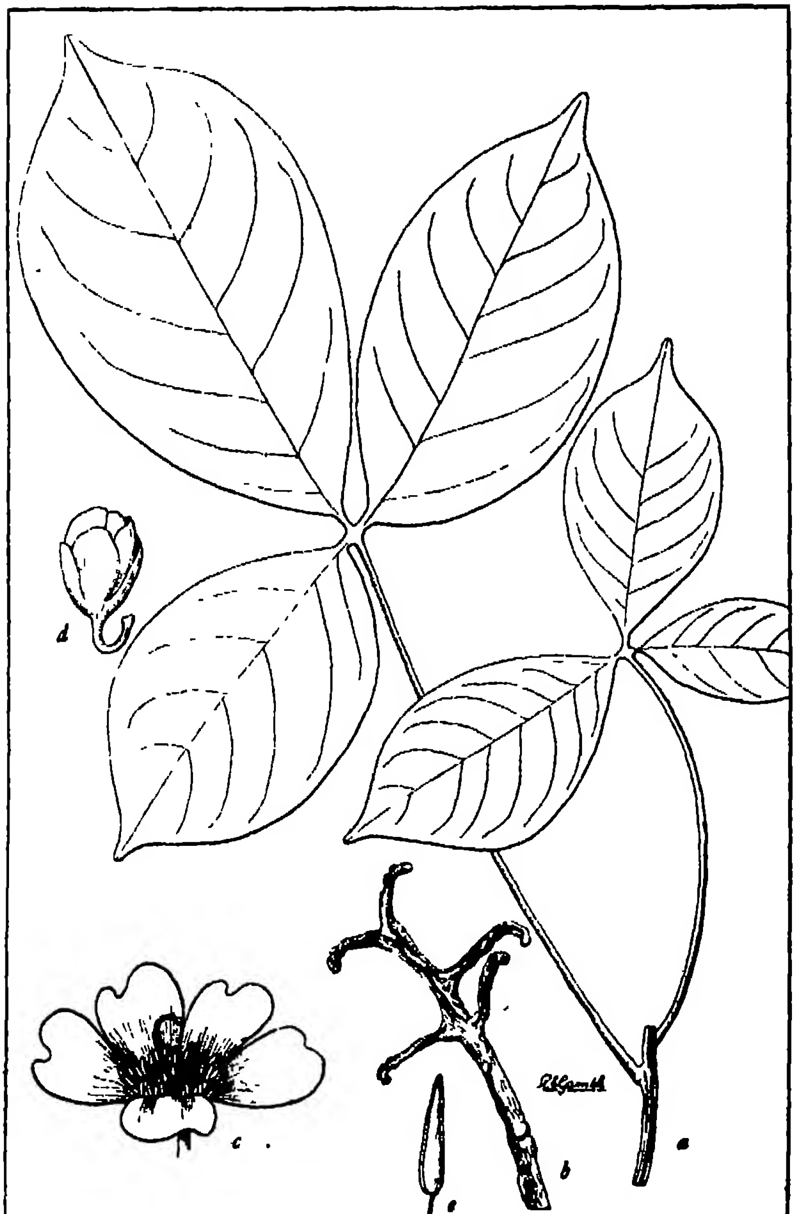

Fig 1 *Maximilianea triphylla* Blake. *a*, leaves, × 1/2; *b*, inflorescence after defloration, × 1/2; *c*, flower, × 1/2; *d*, bud, × about 1/2; *e*, stamen, × 2 1/2.

This species is readily distinguished by its combination of digitate leaves and single apical anther pore. *M. tetrapora*, which is said by Hallier to have the leaves occasionally with three leaflets, is easily separated by its much smaller calyx, much narrower lanceolate leaflets, and anthers with two apical pores.

5. **Maximilianea tetrapora** (H. Hallier) Blake.

Cochlospermum tetraporum H. Hallier, Med. Rijks Herb. **19**: 39. 1913.

?*Cochlospermum zahlbruckneri* Ostermeyer, Rep. Sp. Nov. Fedde **13**: 395. 1914.

Leaves long-petioled, at first sparsely pilose, the leaflets 5 to 7, rarely 3, very shortly petiolulate, the blades lanceolate, membranaceous, with a very narrow acumen at apex, attenuate at base, the two basal ones inequilateral, the middle leaflet 10.5 cm. long, 2 cm. wide; peduncles dichotomous, glabrous; pedicels 2.5 cm. long, glabrous; sepals ovate or elliptic, 10 to 12 mm. long, 5 to 8 mm. wide, the inner densely puberulous and ciliolate; petals obovate, excised, 4 cm. long, 2.5 cm. wide; anthers 3 to 4 mm. long, dehiscing by two apical and two smaller basal pores; capsule fusiform-subglobose, glabrous, 2.3 cm. long, 1.8 cm. wide.

TYPE LOCALITY: Caipipendi Valley, Bolivia.

Not seen; described by Hallier from *Herzog* 1101, collected on dry hills on the left bank of the Pilcomayo at Ibiboba, Bolivia, at an altitude of 400 meters, in November, 1910, and *Herzog* 1242, from the Caipipendi Valley, altitude 1000 meters, December, 1910. As the material of the former number consisted only of three flowers, the latter should be selected as the type.

The short description by Ostermeyer of his *Cochlospermum zahlbruckneri* agrees very well with the full description given by Hallier of *C. tetraporum*, and there can be little question that the two are the same. The former was based on material collected by J. Schuel in 1913 in the Province of Jujuy, Argentina, a region very close to the type locality of *M. tetrapora*. Ostermeyer gives the local name of his species as "palo papel." The reddish brown papery exfoliating bark of *M. tetrapora* is likewise mentioned by Hallier.

6. **Maximilianea orinocensis** (H. B. K.) Kuntze, Rev. Gen. Pl. **1**: 44, as *Maximiliana*. 1891.

Bombax orinocense H. B. K. Nov. Gen. & Sp. **5**: 301. 1822.

Wittelsbachia orinocensis Mart. & Zucc. Nov. Gen. & Sp. **1**: 83. 1824.

Cochlospermum orinoccense (*sic*) Steud. Nom. ed. 2. **1**: 393. 1840.

Tree 16 meters high; branchlets puberulous at apex; leaves long-petioled, the leaflets 5 or rarely 6, lanceolate or oblong, acuminate, at base acute, glabrous above, puberulous along the nerves beneath, the middle one 10 to 18 cm. long, 3 to 6.5 cm. wide; axis of inflorescence thinly tomentose above, the pedicels puberulous; sepals ovate or ovate-oblong, thinly tomentose; flowers 10 to 11 cm. wide; calyx 10 to 18 mm. long; petals cuneate-obovate, excised at apex; stamens free, the anthers dehiscent by 2 terminal pores, capsule 3-locular, about 7.5 cm. long, thinly tomentose outside; seeds twisted, clothed with a long wool.

TYPE LOCALITY: Banks of the Orinoco.

The above description is compiled from the original, based on fragmentary fruiting specimens, and from the descriptions of Martius and Zuccarini and of Eichler. The native name is given as "botuto." It is recorded by Eichler from the provinces of Para (*Spruce* 483) and Alto Amazonas (*Spruce* 494).

In the National Herbarium is a single sheet of fruiting material labeled as this species, collected at Catalina on the Lower Orinoco by Rusby and Squires (no. 256). This has 5-foliolate leaves, with the sessile elliptic acuminate and apiculate perhaps not mature leaflets 10 to 11.5 cm. long or more, 3 to 4 cm. wide, glabrous above, beneath puberulous along the costa and chief veins. The capsules are obovate, slightly umbilicate at apex, 3-valved, 6 cm. long, 3 cm. thick, very densely olivaceous-puberulous and with sparse looser and longer hairs. The seeds are involute, 4 mm. wide, and clothed with a peripheral fringe of rufidulous wool about 9 mm long. In the only other species of which I have examined the seeds, *M. vitifolia*, the much looser and denser wool is attached to the whole outer surface of the seed, on the sides as well as on the back

Fig 2 Seed of *Maximilianea orinocensis*, × 1 Drawn from *Rusby & Squires* 256.

7. **Maximilianea parkeri** (Planch.) Kuntze, Rev. Gen. Pl. 1: 44, as *Maximiliana*. 1891.

Cochlospermum parkeri Planch Lond. Journ Bot. 6: 310. 1847

Petioles very thinly puberulous, about 7.5 cm. long; leaflets 5, oblong, very obtuse, at base long-attenuate, glabrous, the terminal one 5 to 7.5 cm. long, 2 to 3.5 cm. wide, the two lowest less than half as large; peduncle bifurcate at apex, the flowers secund along the branches.

TYPE LOCALITY. British Guiana.

Not seen. Described from material in the Kew Herbarium, collected by Parker.

8. **Maximilianea paviaefolia** (Planch.) Kuntze, Rev Gen. Pl. 1: 44, as *Maximiliana pawiaefolia*. 1891.

Cochlospermum parviaefolium (*sic*) Planch. Lond Journ. Bot 6: 311. 1847.

Cochlospermum parkiaefolium (*sic*) Hook. & Jacks Ind. Kew 1[1]: 570. 1893.

Leaflets 5, sessile, oblong, abruptly acuminate, glabrous, the middle one 7 5 cm. long, 2.5 to 3 7 cm wide; pedicels 1 2 cm. long or more; sepals broadly oblong, obtuse, slightly unequal, rufo-tomentellous outside; petals twice as long.

TYPE LOCALITY: Surinam.

Not seen; based on material in the Kew Herbarium, collected by Hostmann.

OCEANOGRAPHY.—*The problem of physical oceanography.*[1] A. L. THURAS. (Communicated by S. W. STRATTON, Bureau of Standards.)

Physical oceanography is that branch of oceanography which deals with the physical properties of the ocean such as temperature, salinity, density, pressure, velocity and direction of water movements, for the

[1] Received January 31, 1921.

purpose of solving the general problems of oceanic circulation. This article is written with the object of indicating the importance of this subject, especially as regards a part of the North Atlantic ocean, from the light of recent experience, and with the hope that in the near future some systematic plan of work will be undertaken to solve the important dynamical problems of the sea, thereby obtaining a more accurate knowledge of ocean circulation.

During recent years much work of an explorational nature has been carried on in the coastal waters of the United States and Canada. Dr. Henry B. Bigelow, in cooperation with the U S. Bureau of Fisheries, has made these investigations, and the results of his work are published in the Bulletins of the Museum of Comparative Zoology, Harvard University. Several theories of the origin and circulation of our coastal waters have been corrected, and sufficient data have been collected to give a general working knowledge of the subject. Valuable observations have also been collected by observers in Canadian waters, and from these observations some exceedingly interesting theories of ocean circulation have been developed by J W. Sandstrom. Most of this work has also been of an explorational nature.

Since the beginning of the International Ice Patrol an opportunity has been given to extend this work further out into the North Atlantic in the region of the Grand Banks of Newfoundland and in the Labrador Current and Gulf Stream The conflict of the Labrador Current and Gulf Stream south of the Newfoundland Bank causes greater changes in the physical properties of the sea water, only a few miles apart, than occur in any other part of the world. The hydrographical conditions which exist in this locality cause much ice and fog which become a serious menace to navigation during the spring and summer months. The vessels of the U. S. Coast Guard have collected many observations while on patrol in this region. These observations have so far been chiefly of an explorational nature, as the primary purpose of the Patrol has necessarily been to locate ice and convey this information to other vessels. However, from the data obtained and the admirable current charts prepared by Captain C. E. Johnston of the Coast Guard, a fairly accurate knowledge of the movements of ice after passing Newfoundland is available.

In the spring icebergs from the shores of Greenland and Labrador are carried southward in the Labrador Current, their movement being little affected by winds, on account of their small buoyance. Those bergs which are sufficiently off shore to clear the bottom and keep in

the south-flowing branch of the Labrador Current are carried along the eastern edge of the Newfoundland Bank and southward toward the Gulf Stream By measurements of temperature and salinity the course and extent of these streams can be determined, salinity generally being the most reliable indication. The temperature of the Labrador Current is $-1°$ to $+1°$ C., with a salinity of 33 grams of salt per 1000 grams of sea water; the Gulf Stream has a temperature of 15° to 20° C., with a salinity of 36. South of the Grand Bank, where the Labrador Current merges into the Gulf Stream, a large area of mixed water is formed, and at this place the Labrador Current ceases as an individual current In this mixed water almost all the icebergs remain until they melt, and, as this area is usually very foggy from the mixing of the warm and cold waters, it becomes extremely dangerous for vessels. At no time during the last four years has an iceberg ever been located in the unmixed waters of the Gulf Stream, which have a salinity of 36 and a temperature above 15° C. Therefore, if vessels while passing the Newfoundland Bank would keep in this warm salt water there would be little danger from ice, and furthermore such a course would avoid most of the fog.

A comparison of the yearly observations show that the volume and strength of the Labrador Current have a decided influence on the course of the Gulf Stream in this vicinity. In some years the Gulf Stream was found almost up to the southern end of the Grand Bank, in other years as far south as the 40th degree of north latitude, a variation of over 100 miles. This variation in the deflecting power of the Labrador Current must have an effect on the volume of flow of the Gulf Stream to the eastward and also possibly west of this position. A more accurate knowledge of the volume, velocity, and location of these currents from time to time, and correlation with meteorological conditions, might yield results of great interest.

SUGGESTIONS FOR FUTURE WORK

The science of physical oceanography, having passed the period of exploration, should now be undertaken on a large scale with most carefully worked out plans of systematic investigation extending over a long period of time. This can be most effectively accomplished by: (1) international cooperation; (2) development of instruments; (3) establishment of a permanent oceanographic laboratory.

International cooperation.—The oceanographers of Europe for many years have been engaged in the study of the North Sea and surrounding waters. They have built many ingenious instruments and

developed several new methods of investigation. They have been especially interested in the waters of the Gulf Stream, on account of its effect on their climate, and would be very glad to cooperate with us in a careful study of this Stream.

Development of instruments.—In order to obtain a clearer and more complete understanding of the dynamics of ocean circulation, an effort has been made in recent years to develop recording instruments. Hans Pettersson of Göteborg, Sweden, has built a photographic recording current meter which will give a continuous record of current velocity and direction for a period of two weeks. By the use of special anchors and buoys the instrument can be firmly anchored at any depth up to several hundred meters. Dr. R. A. Daly of Harvard University has recently had constructed a thermograph which will give a continuous record of temperature for a week or more; this instrument can be used at great depths in the ocean. The U. S. Coast Guard in conjunction with the Bureau of Standards has designed and constructed a recording salinity apparatus and a recording thermometer which will give continuous records of temperature, salinity and density of the sea water taken from intake pipes below the surface by a moving vessel. As all of these instruments have been developed independently, it might be possible by cooperation and further research to develop a single instrument which would give all of these physical properties at each oceanographic station.

Oceanographic laboratory.—A physical oceanographic laboratory should be established where instruments could be tested and improved and research carried on. This laboratory should be located in Washington, preferably at the Bureau of Standards, where there are facilities for handling and developing work in scientific instruments.

SUMMARY

The physical oceanographic observations collected in our Atlantic waters indicate that that stage in development has been reached which calls for more thorough plans of work extending over a long period of time. These investigations can be accomplished most successfully by international cooperation, development of physical oceanographic instruments, and establishment of a permanent oceanographic laboratory.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

BOTANY.—*A teosinte-maize hybrid.* G. N. COLLINS and J. H. KEMPTON. Journ. Agric. Research. **19**: 1–37. Pls. 7, figs. 33. 1920.

The diminutive variety of pop corn known as Tom thumb was crossed with the teosinte of Florida (*Euchlaena mexicana* Schrad.), using teosinte as the female parent. Eleven hybrid seeds were obtained and six plants were raised to maturity. The first generation plants were intermediate between maize and teosinte The pistillate inflorescences were all four-rowed and the staminate inflorescences resembled those of maize in that they terminated in eight-rowed central spikes.

A population of 127 second generation plants was raised from the seed of a single self-pollinated first generation plant. These plants like those of the first generation were intermediate between maize and teosinte but with greatly extended range of variation. Thirty-three of the characters that differentiated the parents were studied and with one or two exceptions no evidence of alternative or Mendelian inheritance was found.

With respect to the individual characters, the extreme variants approached or even exceeded those of the parents but none of the plants possessed any very large number of the characters of either maize or teosinte. All combinations of characters appeared that might be expected with so limited a number of individuals. There were many instances of coherences or partial couplings but there was an almost equal number of instances where characters derived from different parents showed a tendency to combine more frequently than would be expected as the result of chance. This phenomenon is termed "disherence"

While there appeared to be no imcompatible combinations, there were on the other hand no completely independent characters. A surprisingly large number of the plants combined the abundant production of suckers, characteristic of the teosinte parent, with the sturdy upright character of maize and resulted in very leafy compact plants of a type that should prove valuable for forage purposes. It remains to be seen whether the new combinations can be maintained and made to breed true. J. H. K.

BOTANY.—*Daily development of kernels of Hannchen barley from flowering to maturity.* HARRY V. HARLAN. Journ. Agric. Research **19**: 393–429. Pls. 9, figs. 17. 1920.

The growth of barley kernels is traced from flowering to maturity. By an accurate method of sampling, growth in periods as short as twelve hours has been recorded. Length, lateral diameter, dorso-ventral diameter and weight are all shown to be measurable. The length growth of barley kernels is much more rapid than had been supposed. The full length is reached by the seventh day after flowering. As soon as the length growth is checked a rapid gain in dry matter begins, accompanied by increase in the lateral and dorso-ventral diameters. The indices of growth have proved very valuable in measuring the reactions to water supply and other factors in nutrition.

H. V. H.

BOTANY.—*Development of barley kernels in normal and clipped spikes and the limitations of awnless and hooded varieties.* HARRY V. HARLAN and STEPHEN ANTHONY. Journ. Agric. Research 19: 431–472. Figs. 13. 1920.

The awns of barley are extremely harsh and are objectionable, both in handling the crop and in feeding the straw. Awnless and hooded barleys have not yielded as well as the awned sorts. The physiological value of the awn was tested by clipping the awns from a large number of spikes. Growth measurements taken by the method used in the study of the daily development of kernels of Hannchen barley showed that the awn was necessary for the maximum growth of the kernel. The kernels at maturity were not only smaller but the daily increase in weight was less on the spikes from which the awns were clipped. That this was not due to any injury of clipping was evident from the fact that the growth for the first few days after the removal of the awns was normal, the reduction in the daily increase of dry matter not taking place until the period of rapid starch infiltration had begun. The awns of Hannchen barley normally contain about 32 per cent of ash at maturity. When the awns were clipped much of this ash was apparently deposited in the rachis of the spike, causing the spikes to shatter while ripening. This may explain why the awnless and hooded varieties of barley are more prone to shatter than the awned sorts. H. V. H.

BOTANY.—*Occurrence of the fixed intermediate, Hordeum intermedium haxtoni, in crosses between H. vulgare pallidum and H. distichon palmella.* HARRY V HARLAN and H K. HAYES. Journ. Agric Research 19: 575–591. Pls. 4. 1920.

Hordeum intermedium is considered by the writers to be one of the four species of cultivated barleys. It consists of a number of varieties several of which are in field cultivation in different parts of the world This species has been isolated by the writer from a number of crosses between 6-rowed and 2-rowed barleys. Heretofore plant breeders have considered that such crosses give only three types, the 6-rowed, 2-rowed and the heterozygous intermediate. H. V. H.

HYDROLOGY.—*Surface waters of Vermont.* C. H. PIERCE. U S Geol. Survey Water-Supply Paper 414. Pp. 218, pls 14, figs 2 1917

The rivers of Vermont have figured largely in the growth and development of the State. A brief introduction sketches the changes which have taken place in the utilization of water-power since the early settlements Fortunately, pure water is abundant, so that the higher use for domestic and municipal supply need not seriously interfere with its use for other purposes. Tables are given which show the daily, monthly, and annual run-off for the principal rivers as measured at regular gaging stations. Monthly discharge of Lake Champlain outlet (Richelieu River) for the years 1875–1916 is shown for the purpose of comparing short time records on tributary streams with the probable long term average. Precipitation records at Burlington for the same period are also given. Deficiency tables for several rivers show the number of days on which the discharge and corresponding horse-power per foot of fall were less than the amounts given in the columns for discharge and horse-power. Several maps accompany the report, a map of Vermont showing principal drainage basins and location of gaging stations, scale 1 to 1,000,000, and river surveys of Winooski River drainage basin, scale 1 to 24,000.

A gazetteer of streams is given which lists and describes the streams, lakes,

and ponds which are shown and named on topographic maps of Vermont and such other maps as are available for areas not yet covered by topographic maps. In this list are included nearly three hundred lakes and ponds and over five hundred and fifty streams. C. H. P.

PALEONTOLOGY.—*The fauna of the Cannonball marine member of the Lance formation.* TIMOTHY W. STANTON and THOMAS WAYLAND VAUGHAN. U. S. Geol. Survey Prof. Paper **128-A**. Pp. 67, pls. 10, figs. 3. 1920.

The Cannonball member is the latest marine deposit known in the Great Plains province and thus adds one more item to the record of the sea's advances and retreats which mark the diastrophic history of the region that includes the Great Plains and the Rocky Mountains. It is intimately associated with some of the continental deposits which lie near the boundary between Cretaceous and Tertiary and concerning whose exact age there has been and still is difference of opinion. It lies immediately beneath the Fort Union formation and rests on continental deposits of the Lance formation, which in turn overlie the marine Cretaceous Fox Hills sandstone. Its fauna is strictly marine and includes 2 species of Foraminifera, 6 of corals, 60 of Mollusca, and 2 of sharks.

Geographically and historically the Cannonball member is much more closely connected with the Cretaceous than with the Eocene, for the reason that it is in the midst of an area that was covered by the sea practically throughout Upper Cretaceous time, while it is a thousand miles distant from recognized marine Eocene deposits The conclusion is therefore reached that the Cannonball marine member and consequently the whole of the Lance formation is of Cretaceous age. R. W. STONE

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

BOARD OF MANAGERS

The 244th meeting of the Board was held on October 25, 1920. The publication of a new edition of the "Red Book" (the directory of the ACADEMY and its affiliated societies) was authorized. At the request of Dr. GEORGE F. BOWERMAN, Librarian of the Public Library of the District of Columbia, a committee consisting of the president and resident vice-presidents was appointed to compile a list of popular books in science. The following *Committee on Meetings* for the season 1920–21 was announced: A. H. CLARK, *Chairman*, G. N. COLLINS, E. F. MUELLER, G. W. STOSE, E. T. WHERRY. Routine business was transacted at the 245th meeting on November 29, 1920. The question of increased rates for the assembly hall at the Cosmos Club for the ACADEMY and its affiliated societies was considered at the 246th meeting, December 27, 1920.

At the 247th meeting on January 24, 1921, the following committees were appointed: *Committee on Membership:* H. L. SHANTZ, *Chairman*, L. H. ADAMS, S. J. BARNETT, D. F. HEWETT, WALTER HOUGH. *Executive Committee:* The President, Corresponding Secretary, and Treasurer; F. V COVILLE, and F. B. SILSBEE. *Editor of the Journal, 1921–1923:* SIDNEY PAIGE. The *Associate Editors* were reappointed for 1921, and G. W. STOSE was appointed to succeed Sidney Paige as representative of the Geological Society. A budget for 1921 was approved, with a slight increase for publication of the JOURNAL. It was announced by the Editors that the cost of publication of the JOURNAL would be greater in 1921 by about 70 per cent, and that on account of the limited funds available it would be necessary to decrease the number of pages, but that the amount of material would not have to be correspondingly decreased as certain economies could be effected by increasing the size of the printed page and in other ways. A request from the American Metric Association for support for certain metric system bills before Congress was declined as being contrary to the ACADEMY's policy. The following *Resident Vice-Presidents* were elected· C. HART MERRIAM, Anthropological Society; H. C. MACATEE, Medical Society.

The following persons have become members of the ACADEMY since the preceding report in the JOURNAL (August 19, 1920, p 417):

Prof. JAMES ROWLAND ANGELL, Carnegie Corporation, 576 Fifth Ave, New York City.

Mr. HENRY WALTER BEARCE, Bureau of Standards, Washington, D C.

Dr. CHARLES THOMAS BRUES, Bussey Institution, Forest Hills, Boston, Massachusetts.

Miss JULIA GARDNER, U. S. Geological Survey, Washington, D C.

Dr. WILLIAM JACOB HOLLAND, Carnegie Museum, Pittsburgh, Pennsylvania.

Dr. EDWIN PECHIN HYDE, Nela Research Laboratory, National Lamp Works of the General Electric Company, Cleveland, Ohio

Prof. VERNON KELLOGG, National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

Prof. CLARENCE ERWIN McCLUNG, National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

Dr. DANIEL TREMBLY MACDOUGAL, Department of Botanical Research, Carnegie Institution of Washington, Tucson, Arizona.

Dr. WILLIAM FREDERICK MEGGERS, Bureau of Standards, Washington, D. C.

Mr. SYLVANUS GRISWOLD MORLEY, Carnegie Institution, 16th and P Streets, Washington, D. C.

Maj. Gen. GEORGE OWEN SQUIER, U. S. A., Signal Corps, War Department, Washington, D. C.

Dr. CLARK WISSLER, National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

ENTOMOLOGICAL SOCIETY

329TH MEETING

The 329th meeting was held March 4, 1920, at the Cosmos Club, with President WALTON presiding and 21 members and 3 visitors present.

Program

WM MIDDLETON: *Comparison of larval folds and adult sclerites in the saw-flies.*

This paper dealt with the structure of the immature forms of *Pteronidea ribesii*, treating especially the limits of a segment, the composition of its tergum and pleurum, and the relations existing between larval and adult parts. Particular attention was given to the transformation of the prepupa to the pupa, and it was from observations during this phase of the metamorphosis that the indications of the homologies suggested were found.

The structure of the saw-fly larval body was studied and it was concluded that the segment is composed of four folds, three of which are armed and always have a place in the exterior structure of the larva, and were shown to develop into adult sclerites, while the fourth is never armed, is concealed in some saw-flies, functioning as intersegmental skin, and was shown to be represented in the adult also as a connective membrane. The folds are defined by infoldings of the skin to which muscles are attached and the muscles as well as the arrangement of these folds throughout the whole body determine the limits of the segment. The interpretation of the segment thus arrived at applies to the thorax as well as to the abdomen and to other saw-fly larvae as was attested by several examples.

The study of the metamorphosis brought out several interesting changes in the prepupa preceding pupation, and the homologies were based on the changes exhibited by prepupae under daily observations together with some dissections of more advanced prepupae. Following a table of the homologies the paper concluded with a brief summary of the more important evidence supporting the homologies indicated and some suggestions as to the probable causes of the changes in segment limitation between larva and adult.

This paper was copiously illustrated by drawings showing the correlation of the larval and adult structures.

Discussion.—Mr. ROHWER noted that if the conclusions were correct this was another case of unusual change in the thorax of the Hymenoptera. When the first morphologist stated that the first abdominal segment became a part of the so-called thorax of the Clistogastra there was some doubt in the minds of many. This doubt was, however, easily disposed of by the presence of the spiracle on the propodeum. The borrowing of part of the metanotum of the larva by the mesonotum of the adult is not as easily proven as the transferal of the first abdominal segment to the "thorax" of the Clistogastra. When the composition of the adult mesonotum is considered, and especially when its bulk is compared with the mesonotum of the larva such a transfer does not seem unreasonable, and from the evidence furnished by saw-fly larvae and adults it seems certain that Mr. Middleton's conclusions are correct.

Notes and exhibition of specimens

MR. R. E. SNODGRASS discussed the mouthparts and the alimentary canal of the periodical cicada, on the basis of additional observations made since his paper presented at the 327th meeting of this Society. The alimentary canal of the adult cicada has an arm of the stomach forming a loop from the

rear end to its middle where it penetrates between the stomach walls (not into stomach lumen), goes forward, unites with intestine, and the latter emerges at top of stomach. The Malpighian tubules arise within the stomach walls and emerge at the constriction between the two stomach compartments.

It appears to be impossible in any way to homologise the connections of the mouth setae to the head and their internal apodemes and muscle attachments with these parts in biting insects. Yet all students of their embryological development, except one, agree that the setae are the true mandibles and maxillae. If so the details of their transformations need to be followed more closely than has yet been done.

Mr. C. T. GREENE presented a note on the larvae of the flies of the Stratomyid genus *Hermetia*. The larvae of this genus are scavengers and have been found in various places, as follows:

Hermetia chrysopila Loew, a scavenger in holes in *Opuntia* made by other insects, and in other decaying vegetable matter. *H. hunteri* Coq., habits same as *H. chrysopila*. *H. illucens* L., in wax in beehives, in latrines, and in decaying vegetable matter. Dunn reports this species breeding in large numbers in a human cadaver in the Canal Zone.

Larvae of *Hermetia sp.* were found in raw rubber at Para which was shipped to England. The larvae were presented to the U. S. National Museum by Dr. C. GORDON HEWITT of Canada.

330TH MEETING

The 330th meeting was held April 1, 1920 at the Cosmos Club, with President WALTON in the chair and 27 members and 2 visitors present.

Program

A. D. HOPKINS: *The bioclimatic law and its application to research and practice in entomology.*

The results of detailed studies of the codling moth from Maine to California and New Mexico were made available to the writer by Dr. A. L. QUAINTANCE, with a request for information on the application of the bioclimatic law to the mapping of the distribution of the codling moth and its generations, the forecasting of spraying dates, etc

The methods utilized and the results were described and illustrated, and it was shown that forecasts could be made within the range of allowable error for any given place within the United States as to

(*a*) The dates on or near which the first, maximum, and last hatching of the eggs of the first and subsequent seasonal generations of the codling moth may be expected to occur,
(*b*) the number of generations expected;
(*c*) the optimum time to spray,
(*d*) the latitude and altitude limits of distribution of the insect,
(*e*) the altitude limit of each number of complete generations of hatched eggs

Date constants of the egg-hatching were computed from the table of constants for each of the six stations utilized, and when these were compared with the recorded dates for all years and all events the average difference between the recorded and the constant dates was found to be within a range of error allowable for local influences, etc. Similar computations for the falling of the apple petals and the thermal meannormal for April to July, inclusive, at each of the stations gave similar results. Thus the computations from the falling of the petals and the thermal mean constants served as checks on the computations from the egg-hatching constants.

A table of altitude and latitude limit constants was prepared from which the altitude limits were computed for the several stations and when these were compared with the records they were found to closely approximate them. This served as a basis for making maps of the distribution of the generations and examples of such maps were exhibited.

It was concluded that, if the computed or forecasted dates for the hatching of the eggs of the several generations, the dates for the falling of the apple petals, the thermal means and the altitude limits for the several generations, agreed so closely with the records from six widely separated stations, similar forecasts from the same tables for any place within the United States should come close enough to the actual date or altitude limit for all practical purposes. It appears safe to assume, therefore, that with records from a few representative places in a State or the United States fairly reliable information on these and similar problems in entomology can be forecasted for any place and thus avoid a large amount of local investigation.

A. T. SPEARE: *The relation of Fungi to insects.*

It was pointed out that fungi are associated with insects in several ways. (1) An association in which insects prey upon fungi. (2) The commensalistic association. (3) The symbiotic relationship. (4) An association in which fungi are parasites upon insects. Examples of the first three types were briefly considered. Examples of the fourth type of fungi that live as parasites upon insects were considered in some detail, particularly with reference to the pathogenic forms. Lantern slides showing many rare exotic entomogenous fungi were shown.

331ST MEETING

The 331st meeting was held on May 6, 1920, at the Cosmos Club, with President WALTON in the chair and 34 members and 8 visitors present. Dr. FRANZ SCHRADER was elected to membership.

Program

J M. ALDRICH *Bot flies and their biology.*

Dr. ALDRICH summarized what is known of the host relations both as to the species of the host, the oviposition habits and methods of ingress into the body of the host, and the subsequent development of the immature stages.

J. J. DAVIS: *The Japanese beetle and operations under way for its control.* This was a statement concerning the work under way at Riverton, N. J., looking to the control of this introduced pest. Many photographs of control operations were exhibited.

Dr. F. KÖLPIN RAVN, Professor of Plant Pathology in the Royal College of Agriculture at Copenhagen, Denmark, was invited by the President to address the Society. Dr. Ravn spoke on the desirability of cooperation between entomologists and plant pathologists. He brought out the close relationship between insects and the organisms causing diseases of plants, citing some very striking examples of the interdependence between the two factors. He expressed the opinion that the well-trained plant pathologist should have a good knowledge of zoology, systematic botany (including mycology and bacteriology), as well as plant physiology, while specializing in one subject or another. This he thought necessary to enable the pathologist to determine at once all of the more common diseases and injuries and to give advice as to remedial measures.

332ND MEETING

The 332nd meeting was held at the Cosmos Club, June 4, 1920, with Vice-President A. B. GAHAN in the chair and 22 members and 5 visitors present.

Corresponding Secretary-Treasurer S. A. ROHWER reported on the final settlement of the will of the late FREDERICK KNAB, under the terms of which the Society was the residuary legatee. By this the Society adds some $1400 to its publication fund. Mr. ROHWER also read a letter from two members of the Zoologische und Botanische Gesellschaft of Vienna, explaining the difficulty they were having in securing food and offering to exchange portions of their valuable collection of cavern insects for food parcels. After some discussion the Society authorized the Treasurer to solicit subscriptions, leaving the selection of the insects in the exchange to the owners.

Dr. ADAM BÖVING announced the death from blood-poisoning of Dr F. KÖLPIN RAVN of Copenhagen at East Orange, N. J., on May 25th.

Notes and exhibition of specimens

Under the title of *The introduction of a serious pest*, Mr J. A. HYSLOP announced the finding of the injurious wire worm, *Agriotes lineatus* L., in the United States. A large shipment of potatoes from Copenhagen, consigned to New York City, was inspected by Port Inspector D. G. TOWER on February 2, 1920, and a wire worm was found in one of the tubers. For other reasons than the insect pest, these potatoes were confined to local consumption so the danger of this insect being established by this shipment is very slight. *Agriotes lineatus* is probably one of the most troublesome pests to field grown crops in Europe, especially sugar beets, potatoes, carrots, and all the small grains. It is distributed throughout northern Europe and the British Isles, and it seems remarkable that it has not become established in this country through the large importations of potatoes which we annually receive from Europe.

Mr. E. A. SCHWARZ stated that he had recently received alive what was probably the larva of this species in soil around rose bushes from Europe.

Mr. ROHWER presented a note by WILLIAM H. FOX, a former member, recording the occurrence of the spider *Lathrodectes mactans* Fabr in northern New Hampshire. Dr. Fox's note is as follows:

"In July, 1918, I was sitting reading on the upper porch of my cottage at Twin Lakes (Little Sunapee), New Hampshire, when I noticed, just outside the wire screening which protected all the opening of the porch, a female *Lathrodectes mactans*, very busily making a web. I moved up until I was less than 18 inches from the spider and watched her for some time at her work The web was very irregular, of many crossed threads, but not at all thick. In size I should judge it to be roughly, 4 ft by 5 or 6 ft. Unfortunately, the porches were so well screened it was impossible to procure the spider, but as I watched her for some fifteen minutes at close range there could be no mistake in the identification The web remained *in situ* for some time, but although I watched a good many times, I failed to again see the spider This is the only adult *L mactans* that I have ever seen in New Hampshire, but I have procured the young from the mud nests of a species of *Sphex*, in southern New Hampshire (Hollis) "

Mr. C. H. RICHARDSON reviewed two recently published papers by Dr. AUGUST KROGH of the University of Copenhagen on the physiology of respiration in insects (*Pflügers Arch. Gesamte Physiol.* 95–112, 179..1920), which are of interest to students of insect physiology and to those engaged in studies on gaseous insecticides. The conclusions reached by this author are that gas diffusion is often the only method by which the tracheal air of insects is renewed; that in some forms such as very active adult insects or those having

large tracheal trunks, air sacks, etc., mechanical ventilation, accomplished by body movements, supplements gas diffusion. But even in these forms gas exchange in the finer tracheal branches must be accomplished by diffusion. The *Dytiscus* larva is a type which shows both mechanical ventilation and gas diffusion.

Mr. E. R. SASSCER discussed Mr. RICHARDSON's note in its relation to disinfection with poisonous gases. In reply to questions he stated there is 30% more gas in sodium cyanide than in potassium cyanide, and that dormant insects are more resistant to gas poisoning than active insects.

Mr. WM. MIDDLETON presented *Some notes on the terminal abdominal appendages of saw-flies*, taken from a paper bearing the above title, which will be published elsewhere.

Mr. H. K. PLANK exhibited adult specimens of a new pest of the cranberry, the cranberry root weevil, *Geoderces incomptus* Horn, from near Cranberry Station, Washington, and showed photographs from life of the eggs, larvae, pupa, and adult, also of the female in the act of ovipositing in folds of a "buck brush" leaf, *Spiraea douglasii*, a common bog plant. He described briefly the work o the larvae and adults, showing photographs of larvae feeding on the small roots of the cranberry just beneath the surface of the bog, the destructiveness of the larvae, and the adults in the act of feeding on the terminal leaves of the cranberry upright.

Mr. PLANK also exhibited specimens from Seaview, Washington, of a species of *Spicaria*, a new fungous disease of the pupae of the blackhead fireworm, *Rhopobota naevana* Hn. The identification of this insect was made by CARL HEINRICH of the U. S National Museum. It is the same species that occurs on the bogs of the east and in Europe, of which *vacciniana* Pack. is a synonym. This fungous disease attacks the pupa in its loosely constructed cocoon in the trash and leaves beneath the vines and becomes apparent about early or mid August.

Mr. PLANK called attention to the single generation of *Rhopobota naevana* Hn. on one bog near Cranberry Station, Washington, as compared with two and three generations of the same species on other bogs in the same general locality. The range of the daily temperature on the former is somewhat greater, and this bog is also somewhat more wind-swept than the bogs on which two and three generations exist. Specimens of adults were exhibited.

Mr. L. O. JACKSON told of an encounter observed by his mother between a bumble bee and a white-faced hornet (*Vespa maculata*), in which the bumble bee came off victorious.

A note on *Hymenoptera at the British Museum* by T. D. A. COCKERELL was read by Mr. ROHWER, as follows:

"When I visited the British Museum about 15 years ago, I found Col. BINGHAM arranging the ants, but the bees had never been rearranged since the death of F. SMITH about 26 years before. The progress made since 1905 is remarkable, and it will be of interest to quote a summary from a recent (Nov. 26, 1919) letter received from Mr. ROWLAND E. TURNER:

"'MEADE-WALDO had practically finished the bees before his death, including the incorporation of the Biologia material except the *Prosopis* group. They now occupy 12 cabinets; Diplotera 4, Sphegidae 7, Psammocharidae 6, Mutillidae, Thynnidae, and Scoliidae 6; so that Aculeates are pretty well incorporated up to date excepting ants and Mutillidae. I have recently got the

Braconidae into something like order, also the Evaniidae, etc., and DODD has arranged our exotic Proctotrupidae. MORLEY has done portions of the Ichneumonidae, and MORICE has nearly completed the saw-flies. The exotic Hymenoptera altogether occupy 70 cabinets now, which is a great change since I first came here in 1905 But the collection is still a very small one compared to what it ought to be, as from many regions we have no recent material '

"The death of Mr MEADE-WALDO was a very severe blow to the Museum and to hymenopterology. The most important accessions to the collection of Hymenoptera are doubtless the collections obtained by Mr TURNER in Australia, which are extremely rich in new and interesting species Mr. TURNER is now off to South Africa, where he is sure to make large and important collections "

In discussing this note Mr. ROHWER spoke of the *Hymenoptera at the National Museum*, as follows "While it is undesirable, as well as unprofitable, to make comparisons, I feel that the following remarks may be of some interest at this time because of the short note by Prof. COCKERELL

"Four years before the Division of Insects of the National Museum was formally started, and coincident with the time when Riley deposited his collection in the old building of the National Museum, W. F. KIRBY edited his first volume of the Hymenoptera of the British Museum This volume dealt only with the saw-flies Thirty years prior to that FREDERICK SMITH had catalogued and described the Aculeate Hymenoptera of the British Museum and had published his results in five volumes, extending from 1851 to 1857, as a catalogue of the hymenopterous insects.

"The British Museum has developed naturally along the lines of a museum Their hymenopterous collections have been accumulated by collectors and students of habits and, of course, they have amassed great quantities of material, wasps, bees, and other Aculeates The National Museum collection on the other hand was developed because of and to support agriculture Its greatest advances have been made in parasitic groups, so where the British Museum is weakest, the National Museum is strongest, and I think we can say with assurance that the collection of parasitic hymenoptera in the National Museum is excelled by none It formed the basis of all of Ashmead's monographs, and there is no institution whose collection of Chalcids can compare in any way with that which has been amassed by agricultural entomologists in the United States

"The collection of Hymenoptera in the National Museum is not arranged in as good order as we might wish because there are many more undetermined specimens than there are determined specimens About a year ago we made a rather careful inventory of the adults and found that the collection contained 17,638 species, of which 8,566 were represented by types There are 131,906 determined specimens, and of the undetermined 361,851 The total number of specimens in the Museum was approximately a half million when we made our inventory a year ago One feature which our collection has which, I believe, is not developed to any degree in any other institution, is the alcoholic collection of immature stages We workers here feel sure that there is much to be desired and there are many gaps which need filling, but if we visit other institutions and see how little they have, we are forced to realize that the alcoholic collection of immature stages is by far the best available to students. This is especially true of the immature stages of the saw-flies.

"Because of the incomplete arrangement of the collection, it is impossible to definitely state the number of cases the arranged collection would occupy. To give some idea I think we can justly give the number of cases which are allotted to the various groups The allotment of room does not allow for any expansion and is an estimate which covers only the actual amount of space needed to arrange the collection already in hand. Our unit is a double-columned steel case containing 50 drawers approximately 18 inches square The saw-flies occupy three cases and they are fairly well arranged The Vespoids have two cases allotted to them; the Mutilloids three-and-a-half cases, the Sphecoids three cases, the Ants four cases; the Bees five cases, the Braconids three cases; the Ichneumonids five, Cynipoids each two; and the Chalcids five"

Mr E. A. SCHWARZ spoke of the Tenebrionid genus *Epitragus*, the species of which are commonly found on living plants, where they feed on scale insects. Mr BARBER had dissected a specimen of a Florida species, taken on orange, and found scale insects in its crop.

Mr. H L. SANFORD announced that Brood 19 (13-year race) of the periodical cicada had made its appearance in Alabama, Missouri, North Carolina, Tennessee, Oklahoma, and possibly Texas. Mr. E A SCHWARZ stated that the recording of this cicada west of the Mississippi is due to erroneous determination, and that there is in Texas a related species that occurs at the same time as the 13-year brood

Mr. R A. CUSHMAN presented a note on *An external egg-parasite* as follows:

The eggs of many insects are subject to the attack of parasites, but so far as I am aware all such parasites recorded live within the host egg Certain Ichneumonids of the genera *Tromatobia*, *Gelis*, and *Hemiteles* live as larvae in the egg-sacs of spiders feeding on the eggs or young spiders But I believe that no case has been recorded in which a parasite larva reached full growth as an external parasite of a single insect egg. On one occasion I found among a number of eggs of the saw-fly, *Cimbex americana* Leach, several that were being fed upon by hymenopterous larvae, some of which later developed into Chalcids of the genus *Sympiesis*. Whether this is the normal habit of this particular species I do not know Many of the species of *Sympiesis* are parasitic on the larvae of leaf-miners, and the *Cimbex* egg, being placed just under the epidermis of the leaf, may have attracted a parasite normally attacking a leaf-miner.

Mr. H. S. BARBER exhibited specimens of soft-bodied insects and soft parts of insects that he had prepared in such a way as to retain the natural form in the dry state.

Mr A B. GAHAN spoke of the difficulty of distinguishing species in the chalcid genus *Anastatus* and of the hosts of the various species.

Mr S A. ROHWER told of a carpenter bee that he had observed working at all hours except 5 to 6 a m., and stated that Aculeate Hymenoptera do not ordinarily work at night. Mr BARBER stated that he had known yellow jackets to stay away from the nest all night

R. A. CUSHMAN, *Recording Secretary*.

SCIENTIFIC NOTES AND NEWS

The Pick and Hammer Club met at the Geological Survey on February 26. President W. W. ATWOOD of Clark University spoke on *The Quaternary geology and the physiography of the San Juan region of Colorado*

The interchange of publications between Germany and the United States, which was suspended when this country entered the World War in 1917, has been resumed by the International Exchange Service of the Smithsonian Institution.

The Division of Insects of the National Museum has recently acquired specimens of a minute subterranean Arthropod, belonging to the class *Myrientomata*. This class, which differs from insects in having no antennae, was hitherto represented in the collection only by four specimens of an Italian species The new local specimens were taken by Messrs. BARBER and MANN, along the Potomac. It is probable that species of this group are not rare, but because of their minute size and subterranean habit are usually overlooked by the collector

The Petrologists' Club met on February 15, and discussed papers by M. I GOLDMAN on *Early stages of metamorphism in sedimentary rocks*, and D F. HEWETT on *Bentonite*.

Dr CHARLES H HERTY, editor of the *Journal of Industrial and Engineering Chemistry* and chairman of the committee to cooperate with the Chemical Warfare Service, gave a lecture on *The Reserves of the Chemical Warfare Service* at the National Museum, at 8 p m, Monday, February 21. The lecture was given under the auspices of the National Research Council, and was accompanied by a popular exhibit emphasizing the importance of fundamental research in chemistry and its relation to national defense, medicine and industry. This exhibit was later opened to the public at the offices of the Council, 1701 Massachusetts Avenue

Mr. L. W. WALLACE has been appointed executive secretary of the American Engineering Council, the executive body of the Federated American Engineering Societies

The second annual convention of the Federal Department of the American Association of Engineers was held at the New Ebbitt Hotel, February 28 to March 2.

The Division of Insects of the United States National Museum has recently received an interesting collection of subterranean and cave-inhabiting Coleoptera, which contains 244 specimens, representing 100 species, all of which are new to the National Collection. This accession came from two Austrian entomologists who have made a specialty of those obscure and unusual beetles so abundant in the caves of Europe Last year these two gentlemen, Professor OTTO SCHEERPELTZ and Professor EMIL MOCZARSKI, addressed a letter to the Entomological Society of Washington, in which they offered to sell their valuable collection for food drafts By means of a private subscription taken among the various members of the Society, a sufficient sum was realized with which to purchase a number of food drafts, and at the time of mailing these, Professor Scheerpeltz and Professor Moczarski were informed that the Society would be glad to accept for the collection of our National Museum specimens from their duplicates The splendid sending mentioned above is the result, and has been accessioned as a gift from these distinguished Viennese entomologists. (S. A. R.)

Major J. W. BAGLEY of the Corps of Engineers, U. S. Army, who was formerly with the U. S. Geological Survey, has been assigned to duty at the Air Service Engineering Field at Dayton, Ohio, as representative of the Engineers in experimental work connected with the adaptation of aerial photography to mapping.

Mr. EDWARD CHESTER BARNARD, member of the International (Canadian) Boundary Commissions, died on February 6, 1921, in his fifty-eighth year. Mr. Barnard was born in New York City, November 13, 1863. After graduation from the Columbia University School of Mines in 1884 he joined the U. S. Geological Survey, and as topographer and, later, geographer with the Survey until 1915 took part in the mapping of Alaska and many of the western States. In 1915 he was appointed commissioner for the United States in the International (Canadian) Boundary Commissions, with which he had been chief topographer since 1903, engaged in the resurvey of the boundary line along the 49th parallel. He was a member of the ACADEMY and the Geological Society, and was president of the Washington Society of Engineers in 1920.

Mr. FREDERIC PERKINS DEWEY, Assayer of the Bureau of the Mint, U. S. Treasury Department, died on February 10, 1921, in his sixty-sixth year. Mr. Dewey was born at Hartford, Connecticut, October 4, 1855. After graduation from Yale University he became instructor in chemistry at Lafayette College. From 1881 to 1889 he was connected with the U. S. Government, first as chemist with the Tenth Census, then as mineralogist with the Geological Survey, then as curator in the National Museum. After 24 years in chemical and metallurgical patent practice he became assayer of the Mint in 1903. He was a member of the ACADEMY, and was one of the founders of the Chemical Society of Washington, of which he was president in 1893.

Mr. R. N. HARGER, assistant biochemist at the Bureau of Plant Industry, U. S. Department of Agriculture, resigned in September to accept a National Research Council fellowship in chemistry. The research is in organic chemistry, and is being carried on at Yale University.

Mr. HERBERT C. HOOVER of California has been elected a trustee of the Carnegie Institution of Washington.

Mr. J. A. JEANCON has resigned his position as temporary ethnologist in the Bureau of American Ethnology and has accepted a position in Denver as head curator of the Colorado State Museum.

A farewell reception and buffet supper in honor of Secretary of Agriculture EDWIN T. MEREDITH was held at the Raleigh on February 16 and was attended by about 600 members of the scientific and technical staff. The committee in charge consisted of CHARLES E. CHAMBLISS and R. G. PIERCE, representing the Botanical Society of Washington, F. R. QUACKENBUSH, the American Association of Engineers, J. KITTREDGE, JR., the Society of Foresters, and V. K. CHESNUT, the Chemical Society of Washington.

Dr. L. A. MIKESKA has resigned from the Color Laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, to join the staff of the Rockefeller Institute for Medical Research, New York City.

Mr. THOMAS M. RECTOR, formerly in charge of the division of food technology in the Institute of Industrial Research, has been appointed director of the department of industrial chemistry of the Pease Laboratories, Inc., of New York City.

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PHYSICS.—*On the theory of irreversible time effects.*[1] MAYO D. HERSEY, Massachusetts Institute of Technology.

The study of irreversible phenomena has never been carried far in comparison with other aspects of physics. This paper aims to formulate the problem of time effects—meaning transient or recoverable effects as distinguished from permanent changes— and to develop methods of analysis for use in subsequent research. The writer's attention was directed to the importance of this subject in consequence of aneroid barometer investigations[2] at the Bureau of Standards in 1911.

General formulation. When a load X is suddenly applied to an imperfectly elastic body, a certain amount of displacement, x_e, takes place at once, if ordinary inertia effects are excluded. This may be termed the elastic part of the displacement and written $x_e = X/E$, where E denotes the stiffness of the body. But the actual displacement x at any time t differs from this by some small amount y which may be termed the inelastic yield, so that

$$x = X/E + y \tag{1}$$

The yield, y, depends on the whole past history of the loading of the body and so the displacement at any present time t depends on the load history X = funct (τ) for all previous times $\tau < t$.

An absolutely general formulation of the problem of irreversible time effects is, therefore, having given the load-time curve, to deduce the displacement-time curve. When the problem has been solved in this general way the solution will be found to embrace, as particular cases, all such special effects as the discrepancy between static and dynamic modulus; residual displacement after removal of load; phase difference between a periodically varying load and the corresponding displacement; time needed for approaching the cyclic state—a state

[1] Received February 26, 1921.

[2] Described in Phys. Rev 6: 75–76 1915. It is hoped opportunity will be available later for a more extended report on irreversibility, including a detailed discussion of experimental data already collected The present paper is intended only as a brief abstract of the principles involved.

in which the hysteresis loop has an invariable form; or the damping of free vibrations For example, the displacement-load diagram for a given method of loading, $x =$ funct (X), and the hysteresis loop can at once be found by eliminating the time between the load-time curve and the displacement-time curve.

This formulation need not be restricted to elastic lag phenomena. It applies to all irreversible effects measured by some quantity x whose value is fixed by the history of some other quantity X. Thus x might be termed the generalized displacement and X the generalized load. The latter is a more flexible concept than generalized force, because the product Xdx need not represent work. Table 1 shows some of the possible applications of this method.

TABLE 1—IRREVERSIBLE TIME EFFECTS

Phenomenon	Generalized load, X	Generalized displacement, x
Calibration of aneroid barometer	Change of air pressure	Deflection of instrument pointer
Elastic after-effect with torsion	Torque	Angle of twist
Magnetic hysteresis	Magnetizing force	Induction
Residual charge of condenser	E M F	Quantity of charge
Action of selenium cell	Intensity of incident light	Change of resistance
Hysteresis of thermometer glass	Change of temperature	Change of volume

In what follows the terms load and displacement will be used for short to designate X and x respectively, but it is to be understood that all quantities retain their most general significance The analysis will be confined to the determination of y as a function of t, because x can easily be obtained from y by equation (1)

Dimensional theory Let the physical constants needed for specifying the irreversible properties of a body be represented by $C_1, C_2, \quad C_v$ and let X be the load at time τ. Suppose while τ varies from 0 to t the load passes through a maximum range R Then the load history can be specified by R, t, and the geometrical shape of a diagram having X/R and τ/t for coordinates. Therefore

$$y = \text{funct}\ (R, t, C_1, C_2, \quad C_v) \qquad (2)$$

in which the form of the function is unknown, but the same for all processes with geometrically similar load diagrams. As (2) is a qualitatively complete physical equation, it is subject to the usual methods of dimensional reasoning

This leads to several interesting possibilities, notably the reduction of the number of independent variables confronting the experimenter, and the prospect of predicting effects outside the limit of direct measurement by observations on physically similar models.

In equation (2) with its N separate quantities $y, R, t, C_1, \ldots C_\nu$ there are $N - 1$ degrees of freedom, but Buckingham has shown[3] that dimensional requirements diminish this number by k, where k is the number of fundamental units needed for measuring the original N quantities. Now in treating irreversible processes where the physical state is held constant, x, X, and t are sufficient for fundamental units so that $k = 3$. Consider for example a body whose properties are fixed by $\nu = 3$ drift constants B_o, n, and β (defined by equations (7) and (13)). The dimensions of the original six quantities are $[y] = [x]$, $[R] = [X]$, $[t] = [t]$, $[B_o] = [xX^{-1}t^{-n}]$, $[n] = [1]$, and $[\beta] = [X^{-1}]$. Therefore (2) becomes

$$y = B_o R t^n \text{ funct } (\beta R, n) \tag{3}$$

and it is clear that there are now only two independent variables, βR and n, instead of five The procedure for model experiments can also be illustrated by equation (3), letting primed symbols refer to the model, others to the original The condition for similarity is that the model be made from a substance having the same value of n, and loaded over a range R' such that $R'/R = \beta/\beta'$ The yield y at any time t can now be computed from the yield y' observed at time t' by the relation

$$\frac{y}{y'} = \frac{B_o}{B_o'} \cdot \frac{R}{R'} \cdot \left(\frac{t}{t'}\right)^n \tag{4}$$

The load history diagrams for the model and original are to be kept geometrically similar.

Superposition theory. Direct calculation of the yield y at time t is possible on the basis of an assumption which may be called the principle of the superposition of elements of drift By drift is meant the increase of displacement while the load is held constant. Imagine a small load ΔX applied instantaneously to a body which is in a normal state; that is, to a body which has rested undisturbed for a sufficient time so that all previous effects have sensibly died out. What happens? It is a matter of observation that the displacement does not stop with the immediate or elastic part x, but keeps on increasing Under these circumstances, the yield Δy observed after a lapse of time T reckoning from the instant when the load was applied is termed the drift due to instantaneous loading. It can be written

$$\Delta y = \Delta X \cdot F(T) \tag{5}$$

This equation serves to define the drift function $F(T)$, which is a purely empirical characteristic of the body.

[3] This JOURNAL 4: 347–353 1914.

The fundamental physical assumption of drift superposition may now be stated in this way: The yield y at any time t is the algebraic sum of all the elements of drift generated by each previous load increment.

If this assumption is true, the general problem of irreversible time effects can be solved mathematically without further physical information than is already contained in the function F. The assumption implies that if two bodies have the same drift function F, they cannot differ in any of their remaining effects; and while this assumption is probably not precisely true even for moderate loads, it is certainly true as a first approximation, and therefore practically useful.

The following two-constant expressions have been used in aneroid barometer work:

$$F(T) = A(1 - e^{-mT}) \tag{6}$$

$$F(T) = BT^{n} \qquad (n<1) \tag{7}$$

and

$$F(T) = CT^{1/3}(1 - e^{-mT}) \tag{8}$$

while a formula equivalent to

$$F(T) = K(1 - e^{-\alpha\sqrt{T}}) \tag{9}$$

has been proposed by Michelson[4] for the drift due to torsion in a large number of substances The coefficients A, B, C, K, m, n, α may depend on temperature and other physical conditions, including the load X itself; but are required by the superposition assumption to be independent of the load increment ΔX.

The principle of the superposition of elements of drift may be expressed mathematically thus,

$$y = \Sigma\, \Delta X\, F(t - \tau) \tag{10}$$

in which y is the yield at the present time t, while ΔX denotes a load increment applied at some previous time τ. For convenience the argument T of the drift function has been replaced by its equivalent, $t - \tau$. Equation (10) can also be put into the form of a time-integral.[5]

$$y = \int_0^t \frac{dX}{d\tau} F(t - \tau) d\tau \tag{11}$$

[4] *Laws of elastico-viscous flow.* Proc. Nat Acad Sci. 3: 319–323. 1917.

[5] The time-integral was made possible by suggestions of Dr F. B SILSBEE. Acknowledgments are due also to Dr L B TUCKERMAN and Prof P. W BRIDGMAN for valuable suggestions The first attempt at a general solution was completed in 1916 in connection with work on elasticity at Harvard University. It led to a formula which is equivalent to (10) but which was to be applied by the summation of series instead of by integration, and which also differed in that $F(T)$ represented the drift following a gradually applied load.

This is not an integral equation, for there is nothing unknown under the integral sign. It has sometimes been thought that integral equations would be indispensable in solving "heredity" problems, but such does not appear to be the case except when treating inertia.

The fact that the constants in the drift function may depend on the load could be shown explicitly by writing F as a function of two arguments, $t - \tau$ and X. Since the drift constants are sensitive to temperature change, this consideration has special importance for problems of thermal hysteresis where the load is itself a temperature change. It may often be sufficient to express F as the product of two factors, one of which, F_0, is independent of X, so that

$$F(t - \tau) = f(X)\, F_0(t - \tau)$$

and

$$y = \int_0^t \frac{dX}{d\tau} f(X) f_0(t - \tau) d\tau \tag{12}$$

For example, if β denotes the fractional change in B with respect to load,

$$B = B_0(1 + \beta X) \tag{13}$$

so

$$f(X) = 1 + \beta X$$

For vanishingly small loads $f(X)$ approaches unity and (12) reduces to von Schweidler's formula for residual effects in dielectrics.

When $f(X)$ is constant, the integration of (12) by parts gives $y = \int_0^t X\psi(t - \tau)d\tau$ in which $\psi(t - \tau)$ denotes the first derivative of the drift function $F(t - \tau)$, and in which it is understood that $X = 0$ when $\tau \gtreqless 0$. Writing ω in place of $t - \tau$ this reduces to

$$y = \int_0^\infty X\psi(\omega)d\omega \tag{15}$$

which is Boltzmann's equation for the elastic after-effect in torsion wires. Boltzmann's formula is therefore a special case of (12) above, and a physical interpretation has been found for his arbitrary function $\psi(\omega)$ by identifying it as the slope of the drift curve.

Definition of ideal irreversibility. In all cases where some drift is generated whenever the load on a body changes, this fact alone necessitates qualitatively the existence of all the remaining irreversible effects such as the familiar hysteresis loop. Hence, it is of interest to compute the amount of each effect which would accrue from the simple addition of elements of drift even where it is not expected that the whole effect can be attributed to drift. In order to establish

standards of performance for the comparative study of different bodies, a process may be called ideally irreversible if the observed effect is in exact agreement with the amount calculated from the principle of superposition. The departure of an actual process from this arbitrary standard might be taken as a measure of the irreversible peculiarities of the body, just as the deviation of a real fluid from the equation of state of an ideal gas may be taken as a measure of its intrinsic properties

Simple harmonic motion and the cyclic state. As an example of computation by the superposition method, consider a body subjected to a load

$$X = R \sin \omega\tau \qquad (16)$$

If this body follows the drift function (6) with constants independent of load, integrating (11) gives

$$y = \frac{RA}{\sqrt{1 + \left(\frac{\omega}{m}\right)^2}} \left[\frac{\omega/m}{\sqrt{1 + \left(\frac{\omega}{m}\right)^2}} e^{-mt} + \sin (\omega t - \phi) \right] \qquad (17)$$

where $\tan \phi = \omega/m$. From (1) the total displacement x can be found. After sufficient time that the exponential term of (17) has dwindled to an insignificant amount, the cyclic state may be considered established, the displacement then is given approximately by

$$x = \frac{R}{E} \left[l + \frac{1}{2} AE \left(\frac{m}{\omega} \right) \right] \sin (\omega t - \Phi) \qquad (18)$$

where $\tan \Phi = AE(m/\omega)$. The hysteresis loop will be found by eliminating the time ($\tau = t$) between the load equation (16) and the displacement equation (18). Since (16) and (18) represent two simple harmonic motions at right angles, of the same period but differing in amplitude and phase, the hysteresis loop will be an ellipse. The area of this ellipse will represent the energy dissipated into heat per cycle, after the cyclic state has been reached

Calculation of recovery curve. Suppose a load R suddenly applied, kept on for a time interval t_0, then suddenly released. What will be the after-effect z (residual displacement) at an interval t' after the instant of release? Since x_e is now zero, the after-effect will equal the yield y at time $t = t_0 + t'$ due to a load increment $\Delta X = R$ at time $\tau = 0$ followed by a second increment $\Delta X = -R$ at time $\tau = t_0$. Hence by (10)

$$z = R[F(t_0 + t') - F(t')] \qquad (19)$$

Thus the recovery curve can be constructed by making a tracing of the drift curve, inverting it and shifting it along the time axis by an amount t_0. The algebraic sum of the ordinates of these two curves forms the desired curve for z as a function of t'. This method has been applied with fair success to data furnished by Dr. C E. Van Orstrand for the slow stretch in a steel tape over a period of four months, when suspended under tension. The greatest difference between the calculated and observed after-effect at any time during this long period was less than 9 per cent of the initial after-effect.

A similar check on equation (19) should be possible by reference to Michelson's data for torsion. His recovery curve formula may be written[6]

$$z = KRe^{-a\sqrt{t'}}\,(1 - e^{-a\sqrt{t_0}}) \tag{20}$$

Substitution from (9) into (19) gives

$$z = KRe^{-a\sqrt{t'}}\,[1 - e^{-a(\sqrt{t_0 + t'} - \sqrt{t'})}] \tag{21}$$

This, for small values of t', reduces to Michelson's experimental formula (20), but for large values it diverges. It is not possible to make an exact test of equation (19) without reference to the original observations, which were not given in the paper above cited

These examples may suffice to make clear the general purpose of the superposition theory. It is not a molecular theory, neither does it aim to deduce *a priori* anything about the form of the drift function. It presupposes the availability of just such data as Michelson's drift curve (9) and then proceeds to develop the necessary interconnections between the drift and the remaining irreversible effects.

BOTANY *Notes on the genus* Swartzia *in Panama and Guatemala.*[1]

HENRY PITTIER

The genus *Swartzia* of the Caesalpiniaceae contains a large number of species, many of which are closely related, and the genus as a whole is badly in need of revision In the present paper an attempt is made to systematize the representatives of the genus now known from Panama. A little known species of the genus from Guatemala is also described.

[6] *Op. cit.* See also Journ Geol. **28**: ——. 1920.

[1] Received February 11, 1921.

1. REVISION OF THE PANAMA SPECIES

Legume broad, long, and flat; racemes many-flowered, elongate; leaves pinnate, 5-foliolate. (PLATYPODA.) 1. *S. panamensis.*
Legume cylindrical, short; racemes 2- to 5-flowered, leaves mostly 1- or 3-foliolate, rarely 5-foliolate. (STRONGYLOPODA.)
  Leaves unifoliolate. Petiole narrowly alate or scutellate at the apex; petal about 4 cm. in diameter. 2. *S. simplex.*
  Leaves mostly 3-foliolate, sometimes 1- or 5-foliolate.
    Stamens 20 or fewer, not conspicuously unequal. Flowers small, the petal hardly longer than the calyx. 3 *S. arborescens.*
    Stamens numerous, conspicuously dimorphous, the longer ones 10 to 20, the smaller ones numerous.
      Leaflets not over 10 cm. long, lanceolate, the petioles rather broadly winged. 4. *S. trifolia.*
      Leaflets usually larger, ovate, the petioles rather narrowly winged.
        Petal suborbicular, about 2 cm. in diameter. 5. *S. myrtifolia.*
        Petal ovate-cordiform, about 2.5 cm. long and 3 cm. broad. 6. *S. darienensis.*

1. **Swartzia panamensis** Benth. in Mart. Fl. Bras. 15[2]: 38. 1870.

Deciduous (?) tree, 6 to 20 meters high, with short ascending limbs and elongate crown, the trunk seldom over 40 cm. in diameter, often distorted, the bark grayish, smooth.

Leaves 5-foliolate, pubescent, glabrate, with lanceolate-acuminate silky-pubescent caducous stipules; petioles 9 to 13 cm. long, almost terete; petiolules articulate, 4 to 6 mm. long, blades elliptic or ovate-lanceolate, rather long and narrowly acuminate, 8 to 18 cm. long, 3 to 6 cm. broad, dark green above, pale green beneath, the venation sparse, impressed above, prominent beneath, the 9 to 11 primary veins alternate, arcuate, transversely anastomosing.

Racemes solitary in the defoliated axils of the preceding season or in the axils of new leaves, very long (20 to 40 cm.), pendent, many-flowered, the bracts awnlike, up to 10 mm. long, caducous; rachis and pedicels minutely pubescent, the former thick and subangular; pedicels reflexed, clavate, about 2 cm. long; calyx opening irregularly by 4 or 5 reflexed lobes about 1 cm. long. Petal creamy yellow, almost square (31 mm. long, 29 mm. broad), unguiculate, hastate and emarginate at the base, subquadrilobate, with irregular margin, claw narrow, about 6.5 mm. long. Stamens very numerous, the larger ones 6 to 10, erect, with thick filaments 12.5 mm. long, the remaining small ones with threadlike filaments 15 mm long and smaller anthers, their cells more or less parted at the base. Ovary short, flattened, entirely smooth, long-stipitate, with a short, blunt, hardly bent style; stipe 6 mm. long, the ovary and style about 5 mm. long, ovules 8 or fewer.

Legume single, 20 to 30 cm. long, 8 to 10 cm. broad, coriaceous, apiculate, dehiscent, 4- to 8-seeded; pedicel thick, 2 cm. long; stipe 1.5 to 2 cm. long, seeds large, irregularly sublenticular-ovate, 7 to 8.5 cm. long, 6 cm. wide, and 1.5 cm. thick, exarillate, dark brown.

SPECIMENS EXAMINED:

PANAMA: Rocky slopes along Chagres River near Alhajuela, flowers and fruit, May 13, 1911, *Pittier* 3520. Along Trinidad River, Canal Zone, near sea level, flowers, July 20, 1911, *Pittier* 4019. Around Port Obaldia, San Blas Coast, flowers, September 2, 1911, *Pittier* 4324.

Also recorded by Seemann from San Juan de Chagres and Hacienda de Juan Lanas. Seemann describes the racemes as being in pairs, a character not shown by the recent specimens, though these agree in the main with Bentham's short diagnosis. These collections from the shady forests of the littoral plain around Port Obaldia have broader and less coriaceous leaflets than those from the high banks of the Trinidad River or the rocky slopes of the Chagres gorges. In the first locality, too, the tree assumes more frequently an erect, regular shape, with a straight trunk. It seems that only the basal flowers of each spike bear a pistil; this part was missing altogether on several of the specimens I had occasion to dissect, and, so far as my experience goes, the pods invariably grow out of the 5 flowers nearest to the base of the raceme. Usually there is only one pod to each raceme, but two on the same peduncle are not uncommon. Completely developed seeds are seldom found. The trees on the Chagres River bore only new, incompletely developed leaves, although anthesis was rather advanced and even fully grown pods were present. These facts would indicate a deciduous species, the only one reported so far in this heterogeneous and not well defined genus.

2. **Swartzia simplex** Spreng. Syst. Veg. 2: 567. 1825.

Small tree, 3 to 10 meters high, the trunk 10 to 15 cm. in diameter, straight or distorted, with smooth grayish bark, the branching sparse and divaricate.

Leaves unifoliolate, quite glabrous, more or less coriaceous, nitidulous, the primary veins numerous and subparallel; stipules setaceous, 5 to 8 mm. long, caducous; petiole 3 to 15 mm. long, terete and auriculate at the apex when very short, marginate and distinctly articulate at the apex when longest; blades ovate-oblong, rounded or subcuneate at the base, shortly obtuse-acuminate at the apex, 4 to 20 cm. long, 2 to 7 cm. broad, the venation prominent on both sides.

Inflorescences racemose, 2- to 6-flowered, axillary or terminal, 4 to 10 cm. long, the rachis glabrous; pedicels erect, 5 to 20 mm. long, obclavate; buds globose, 7 to 10 mm. in diameter; calyx opening by 4 irregular lobes; petal orbicular, about 4 cm. in diameter, pale yellow; long stamens 8 to 12, the anthers elongate-oblong; short stamens numerous, the anthers also smaller; ovary long-stipitate, quite glabrous, arcuate, 10- to 12-ovulate, the style arcuate and subulate.

Legume oblique-oblong, terete, up to 4 cm. long, 1.5 cm. in diameter, usually 1- or 2-seeded, in the latter case hardly contracted between the seeds.

TYPE LOCALITY. Trinidad.

SPECIMENS EXAMINED.

PANAMA: Chagres, *Fendler* 327. Agua Clara, Canal Zone, along Rio Trinidad, fruit, June 20, 1911, *Pittier* 3984. Culebra, Canal Zone, flowers, January 6, 1911, *Pittier* 2256. Penonomé and vicinity, fruit, March, 1908, *Williams* 396. Marraganti, South Darién, fruit, April 5, 1908, *Williams* 995.

3. **Swartzia arborescens** (Aubl.) Pittier.

Possira arborescens Aubl. Pl. Guian. 2: 934. *pl. 355*. 1775[1].

Tree, 6 to 10 meters high, the branchlets glabrous or pubescent.

Leaves glabrous, 3-foliolate or sometimes 1-foliolate; stipules setaceous;

[1] For full synonymy see Fl. Bras 15^2: 22. 1870.

rachis, including petiolar part, 1 to 4 cm. long, narrowly winged and auriculate at least under the terminal leaflet; leaflet blades ovate or ovate-elliptic, rounded or cuneate at the base, obtusely short-acuminate, subcoriaceous, lustrous, the terminal leaflet 5 to 10 cm. long, the primary veins numerous, parallel, and conspicuous.

Racemes axillary or terminal, the short slender glabrous peduncles with 2 to 4 flowers; pedicels filiform, 1 to 1.5 cm long, bracts small, setaceous; bracteoles very small or none, buds quite glabrous, subglobose, hardly 4 mm. in diameter, petal orbicular, unguiculate, a little longer than the calyx; stamens 18 to 20, almost all equal, twice longer than the calyx, the anthers ovate, ovary stipitate, narrow, glabrous, 5- or 6-ovulate, attenuate to a short style, the stipe a little shorter than the calyx.

Legume short-stipitate, obliquely ovoid, long-acuminate, 4 to 5 cm. long, thick and carnose, seed oblique-ovoid, the aril lacerate, the raphe very prominent

TYPE LOCALITY Near the source of the Galibi River, French Guiana.

This species was collected on Tobago Island by Seemann (no 1687), but I have seen no specimens of it.

4. **Swartzia trifolia** Pittier, sp. nov.

Small tree, 4 to 5 meters high, the trunk 8 to 12 cm in diameter, the branchlets, leaves, and inflorescences entirely glabrous, the bark dark red and smooth

Leaves usually 3-foliolate, seldom 5-foliolate, coriaceous; stipules setaceous, stiff, about 4 mm long; rachis 2 to 5 cm. long, terete, winged-auriculate, the wings broader at the auricles, leaflets subsessile, the blades lanceolate, more or less oblique and rounded at the base, obtusely short-acuminate at the apex, the lateral ones 4.5 to 7 cm long, 2 to 2.5 cm broad, the terminal one 5 5 to 9 cm. long, 2 to 3.5 cm. broad, the primary veins about 16, anastomosing along the margin, the venation conspicuous on both sides

Flowers not known

Fruiting pedicel about 1 cm long, stipe 8 mm. long, fruit glabrous, 1-seeded, ovoid, acuminate, 3.5 cm. long, 1 5 cm broad between the sutures, seed ovoid-subreniform, 2.5 cm. long, brown and lustrous.

Type in the U S National Herbarium, no. 677726, collected on the savanna of La Tortuga, between El Boquete and Caldera, Panama, at an altitude of about 400 meters, in fruit, March 21, 1911, by H. Pittier (no. 3343).

This species is so well characterized by its peculiarly shaped leaves and narrow leaflets that even in the absence of the flowers I do not hesitate to describe it as new.

5. **Swartzia myrtifolia** J. E. Sm. in Rees' Cycl. **34:** *Swartzia* no. 5. 1819.

Small tree, the slender branchlets as well as the leaves and inflorescences glabrous or slightly pubescent.

Leaves 3-foliolate or sometimes 1-foliolate; stipules subulate, 3 to 4 mm. long, rachis slender, marginate and more or less distinctly auriculate below the insertion of the leaflets, 2.5 to 5 cm long; leaflets subsessile, the blades ovate or ovate-oblong, rounded or cuneate at the base, obtusely short-acuminate at the apex, subcoriaceous, nitidulous, the primary veins numerous and prominent on both sides; lateral leaflets 6.5 to 8 cm. long, 3 to 4 cm. broad; terminal leaflet 6 5 to 14.5 cm. long, 5 to 7 cm. broad.

Racemes axillary or terminal, 2- to 5-flowered, about equaling the petioles, bracts small, setaceous; bractlets minute or none, peduncles short; pedicels slender, 1 to 2 cm. long, buds globose, 6.5 mm. in diameter, segments of the calyx 4, reflexed; petal yellow, orbicular, about 2 cm. in diameter; larger stamens 12 to 18, the anthers oblong; smaller stamens numerous, the anthers half shorter than those of the larger ones; ovary glabrous, narrow, recurved, long-stipitate, 8-to 10-ovulate, the style much shorter.

Legume nearly 2.5 cm. long, obliquely ovoid-oblong, short-acuminate.

TYPE LOCALITY: West Indies.

SPECIMENS EXAMINED:

PANAMA: Obispo Falls, Canal Zone, *Hayes*. Pinogana, South Darién, in forest, flowers, June 21, 1914, *Pittier* 6676.

6. **Swartzia darienensis** Pittier, sp. nov.

Small spreading tree, entirely glabrous, 6 to 8 meters high, with short trunk and pendent branches, the bark smooth, grayish.

Leaves 1- or 3-foliolate, membranous; stipules linear, 4 to 6 mm. long, caducous, petioles of the 1-foliolate leaves 5 to 7 mm. long, articulate and provided at the tip with 2 stiff acute auricles, rachis of the 3-foliolate leaves 3 to 6 cm. long, canaliculate, marginate, with acute auricles at the insertion of the leaflets, leaflets petiolulate, ovate-elliptic or broadly lanceolate, rounded or obtusely pointed at tip, the lateral ones 7 to 10 cm. long, 3 to 4 cm. broad, the terminal one and the blade of the 1-f[illegible]te leaves 12 to 16 cm. long, 5 to 6 cm. broad; petiolules 4 mm long, veins very thin, almost parallel, delicately reticulate-anastomosing

Racemes axillary or terminal, often geminate, 3- to 5-flowered, bracts and bractlets linear, minutely pubescent, caducous, rachis 1.5 to 7 cm. long, pedicels 5 to 10 mm. long, clavate, pubescent, segments of the calyx 4, irregular, about 1 cm. long, petal pale yellow, irregularly ovate-cordiform, emarginate at the base, about 2.5 cm. long (including the claw, this 5 mm. long) and 3 cm broad, larger stamens 4 to 9, the smaller ones very numerous, the anthers slightly larger in the former but all alike and broadly ovate or orbicular, with a dark connective, pistil incurved; ovary long-stipitate, 8-ovulate, style a little shorter than the ovary, capitellate.

Legume not known.

Type in the U. S National Herbarium, no 678872, collected on the rocky slope of Mamei Hill, near Gorgona, Canal Zone, Panama, July 6, 1911, by H. Pittier (no 3800).

There is certainly a great deal of confusion as to the segregation of the several very nearly related forms of *Swartzia* in Panama, and the difficulty of separating them is increased by the vagueness of the descriptions and the lack of material. The species just described belongs without doubt to the polymorphous group of *S myrtifolia*, but it seems not to agree with the description of any of the species published

2. A LITTLE KNOWN SPECIES FROM GUATEMALA

Swartzia guatemalensis (Donn. Sm.) Pittier.

Swartzia myrtifolia var. *guatemalensis* Donn. Sm. Bot. Gaz. **33**: 251. 1902.

Section *Pteropoda*. Small tree, the branches slender, glabrous or minutely appressed-pubescent.

Leaves 3-foliolate or often reduced to the terminal blade, glabrous or more or less appressed-pubescent; stipules subulate or linear, minutely pubescent; petioles 1.5 cm. long in the simple leaves, 2.5 to 4 cm. in the compound leaves, glabrous, broadly alate, the wings up to 7 mm. broad, acute or rounded below the insertion of the leaflets; leaflets short-petiolulate, ovate-lanceolate, rounded at the base, obtusely long-acuminate, the main primary veins (of the terminal leaflets) 11 to 14, anastomosing along the margin, prominent on both sides, the intermediate veins numerous and parallel; lateral leaflets 3.5 to 9 cm. long, 1.5 to 4 cm. broad, terminal and single leaflets 8 to 16 cm. long, 3.5 to 6 cm. wide.

Inflorescences 2- to 5-flowered, axillary or terminal, the rachis slender, sparsely appressed-pubescent; pedicels subfiliform, 12 to 15 mm. long; buds subglobose or broadly ovoid, glabrous, about 9 mm. long, calyx opening by 3 irregular segments, almost 10 mm. long, petal short-unguiculate, broadly ovate, 16 mm. long, 22 mm broad; longer stamens 8, the anthers elongate, recurved, smaller stamens numerous and short, ovary long-stipitate (the stipe 10 to 14 mm. long), 6- to 8-ovulate, glabrous, 6 to 8 mm. long, the style straight, subulate, 5 to 6 mm. long.

Legume not known.

Type collected by von Tuerckheim at Cubiquiltz, Alta Verapaz, Guatemala, in flower, May, 1901 (J. D. Smith, no. 7839).

This plant, described by Captain John Donnell Smith as a variety of *Swartzia myrtifolia*, differs from that species in several important particulars, such as the disparity between the lateral and terminal leaflets, the conspicuousness of the main primary veins, the long acumen of the blades, the broad wing of the petiole, the 3-laciniate calyx, the shape of the petal, the 8 long stamens (instead of 12 to 18), and the long-stipitate ovary. These characters are sufficient to justify specific rank for this interesting member of the Guatemalan flora.

OCEANOGRAPHY.—*Practical application of the electrical conductivity method of measuring sea water salinity.*[1] A. L THURAS. (Communicated by S. W. STRATTON, Bureau of Standards.)

Heretofore the only reliable method of measuring the total salt content of sea water has been by chemically titrating for the amount of chlorine present. The relation of chlorine to the total salts being a constant, a measure of the salinity is thereby obtained. Salinity is defined as the number of grams of total salts in 1000 grams of sea water The titration method, being a laboratory method, requires that the samples after collection be stored in suitable bottles until they can be tested on shore. The disadvantages of such a method are: the loss or breakage of samples, possible errors from evaporation and handling, and the great undesirability of not knowing the physical properties of the waters while they are being investigated.

[1] Received January 31, 1921.

During the Ice Patrol of 1920 an opportunity was given to use the electrical method of measuring sea water salinity on board ship. An apparatus consisting of instruments and parts secured from the Bureau of Standards was set up on shipboard and several hundred determinations of salinity were made. The operation of the apparatus was simple and convenient and at no time did weather conditions interfere with the measurements. This apparatus consisted of: a wheatstone bridge, a Leeds and Northrup alternating current galvanometer, a specially constructed electrolytic cell designed for a salinity recorder,[2] a hand regulated temperature bath, and a rebuilt 1/12 horse power direct current motor to give 120 volts, 60 cycles of alternating current when connected to 110 volts direct current. This machine was designed and built by Mr. A. J. Fecht of the Bureau of Standards.

All measurements were made at 25° C. and a table was prepared to give salinities directly from the balanced bridge readings. The complete apparatus was tested each day by standard sea water taken from a supply which had been carefully measured both by a chemical method and a density method[3] before beginning the cruises. This supply of sea water lasted throughout the cruises. The temperature of the electrolytic cell bath could easily be held to within 0.03° C., and the bridge, after balancing the moving coil of the galvanometer so that the center of mass was fairly near the axis of support, could be set to a value corresponding to 0.02 in salinity. No electrical capacity or inductance was necessary for balancing the bridge, and variations in the voltage and frequency of the generator had no appreciable effect on the bridge setting. With the rough apparatus used the determinations were accurate to 0.05 in salinity, or better than 0 02 of one per cent.

Since the electrical conductivity method may be satisfactorily used at sea to measure the salt content of ocean water, attention is directed to the references given in the foot notes which describe an apparatus which will give a continuous record of sea water salinity from a moving vessel. This instrument in conjunction with an instrument to record temperature, which has been constructed, would give the three most important physical variables of sea water, namely, temperature, salinity and density. Such records taken regularly over the same course would show monthly and yearly variations of these physical properties which might be of much scientific value.

[2] See this JOURNAL, 8: 145, 680. 1918.

[3] See this JOURNAL, 7: 605. 1917.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

837TH MEETING

The 837th meeting was held at the Cosmos Club, May 22, 1920, with President SOSMAN in the chair and 50 persons present.

The first two papers of the program were devoted to the general subject *Foreign laboratories and societies*, the speakers being C. E. MENDENHALL and H. L. CURTIS. Mr. MENDENHALL confined his remarks to his observations and experiences in England referring especially to the Royal Society, the Royal Institution and the Physical Society of London Mr. CURTIS spoke of the French societies and laboratories and of the National Physical Laboratory of England.

Discussion Messrs. SOSMAN, CRITTENDEN, HUMPHREYS, BOWIE, and WILLIAMSON took part in the discussion.

The last paper was by W. P WHITE on *Three methods of promoting precision in thermostats* Preliminary publication of this paper appeared in this JOURNAL.[1] The paper was discussed by Messrs MENDENHALL, DICKINSON, MUELLER, and T. S. SLIGH

838TH MEETING

The 838th meeting was held at the Cosmos Club, October 9, 1920. President SOSMAN presided and about 50 members and guests were present. The program was as follows

S J BARNETT *Further experiments on magnetization by rotation.*

This paper is a report of progress in the first part of a general investigation of the relations between magnetization and rotation designed to extend the earlier work in this field, to obtain more precise results, and especially to find out whether negative electricity with the known value of m/e is alone responsible for magnetism

In earlier papers it has been shown that, if the slowly moving electron, with the value of m/e known from other experiments, is alone involved in the Ampéreian vortices, the rotation of a magnetic substance at an angular velocity of one revolution per second is equivalent to placing it in a magnetic field of strength -7.1×10^{-7} gauss directed along the axis of rotation. Two series of experiments made in 1914 and 1915, by a method of electromagnetic induction, gave 3.6 and 3.1, respectively, instead of 7 1, apparently indicating that negative electricity is chiefly responsible, but that positive electricity also is involved. Another alternative, on the assumption of the correctness of the experimental results, is that negative electricity alone is involved, but that it has, for the motions responsible for magnetism, a smaller value of m/e than that determined in known experiments.

Another series of experiments made in 1916 and 1917 by a magnetometer method gave the same sign as before, but gave numbers approximately 5 and 6 in place of 8.1. A few experiments made more than two years ago at the Ohio State University, where the earlier work was done, with copper sub-

[1] This JOURNAL, 10: 429–432. 1920.

stituted for the magnetic substance, indicated that a part of the effect in the magnetometer experiments was due to eddy currents, the effects of which appear to have been completely eliminated in the work done by the method of electromagnetic induction. This probably accounts for at least a part of the discrepancy between the results obtained by the two methods.

In new experiments performed under superior conditions in the non-magnetic experiment building of the Department of Terrestrial Magnetism, by the magnetometer method, considerable improvements have been made in the completeness with which the earth's field is compensated, in the elimination of mechanical and magnetic disturbances, and in other ways. The polar position of Gauss, which was earlier thought impracticable, has been substituted for the equatorial position, as it makes less difficult the elimination of eddy current effects and has other advantages. Eddy current effects have been more thoroughly studied by rotating copper and otherwise The work is still in progress and other tests remain to be applied.

The most extensive observations have been made on a rod of Norway iron (for which observational curves were shown). Many observations have been made on a rod of cobalt, and some on rods of cold-rolled steel. All the rods gave values about one-half of 7 1 instead of 7.1, or even less, as in the experiments on iron by the method of electromagnetic induction, thus again indicating an effect of positive electricity or else indicating that negative electricity alone is involved, but has, for the motions responsible for magnetism, a smaller value of m/e than that determined in known experiments. Satisfactory experiments on nickel have not yet been made.

It is interesting to observe that, while all the sources of trouble have not yet been removed, the method is so sensitive that, in the later part of the night, when extraneous magnetic disturbances are least, the effect can be measured at even very small speeds. Curves between the scale readings for right and left handed rotations and the time were exhibited showing clearly the effect for cobalt at the speed 3/4 revolution per second.

The paper closed with a reference to recent experiments on the converse effect (rotation by magnetization). These experiments, on the theory which has been adopted by the investigators, but which involves an uncertain assumption with reference to the seat of the reaction to the resultant electron momentum produced on magnetization, also appear to indicate an effect of positive electricity or else the participation of negative electricity with a value of m/e different from that hitherto known.

The paper was illustrated by lantern slides, and was discussed by Mr. HUMPHREYS.

S. J. MAUCHLY: *Results of atmospheric electric observations made during solar eclipse of May 29, 1919, and summary of similar observations*

The only atmospheric-electric observations made within the belt of totality during the total solar eclipse of May 29, 1919, appear to have been those by observers of the Department of Terrestrial Magnetism at Sobral, Brazil These observations were in charge of Mr. ANDREW THOMSON, of the Department of Terrestrial Magnetism, who made measurements of the electrical conductivity of the air due to positive and negative ions, respectively. Mr. THOMSON was assisted by Mr. ANTONIO LIMA, a native of Brazil, who had been educated in the United States, and who made potential-gradient observations under Mr. Thomson's direction.

Owing to considerable cloudiness during the first hour of the eclipse, the conditions at Sobral were not so favorable for the detection of an eclipse-effect as those which favored the observations made for the Department of Terrestrial Magnetism by the author and others, in connection with the eclipse of June 8, 1918. However, in spite of the fact that clouds still remained, they did not obscure the Sun after a time corresponding to about 15 minutes before totality, and it was possible to note, in the results for the remainder of the eclipse, variations of the several elements similar to those observed at Lakin in June, 1918.

Briefly enumerated, the Sobral results indicate:

(*1*) A general potential-gradient *minimum* beginning just before totality and continuing until about 20 minutes after totality. The values during this period were abnormally uniform and about 20 per cent lower than those which obtained during the equal periods just preceding and following the one under consideration. (*2*) For both the positive and negative conductivity as determined by the ordinary Gerdien apparatus, a *maximum* of the order of 20 per cent, which set in just after totality and continued throughout most of the period of potential-gradient minimum. (*3*) That the air-to-earth current-density, as computed from potential-gradient and total conductivity, remained near the normal station value throughout the period in which obscuration exceeded 50 per cent, and was more constant than during any equal period of the forenoon.

In view of the general agreement between the results obtained at Lakin, in 1918, and at Sobral, in 1919, a detailed study was made of all available data concerning atmospheric-electric observations made during solar eclipses. It was found that the evidence as a whole is of a very conflicting nature unless special care is taken to note the apparatus and methods employed by the various observers, and the meteorological (especially cloud) conditions which prevailed during the observations.

Following these lines it was found that almost without exception the conditions attending previous observations were less favorable for the detection of an eclipse-effect than at Sobral and Lakin, and in nearly all cases where conditions were reasonably favorable the results for potential-gradient and conductivity were in substantial agreement with the foregoing.

The paper was illustrated by lantern slides.

L. A. Bauer: *Results of magnetic and meteorological observations during solar eclipse of May 29, 1919* (illustrated).

With the aid of magnetic data from nine stations within the region of visibility of the solar eclipse of May 29, 1919, five of these stations being those at which observations were made by the expeditions of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and from about eighteen cooperative stations distributed outside the region, the following main conclusions were drawn:

(*1*) Magnetic effects of appreciable and determinable magnitude were observed during the solar eclipse of May 29, 1919, at stations inside the region of totality as well as at certain stations in the sunlit region, the magnitude and character of the effects being similar to those observed during previous solar eclipses and showing a distinct connection with the eclipse circumstances. The magnetic data for stations in the night region of the globe did not exhibit similar effects.

(2) There were two principal variations (with some subordinate ones), as shown especially at stations near the totality-belt, having periods approximately that of the entire eclipse (5h. 10 m.) and that of the local eclipse (on the average about 2 hours from first to last contact). There are evidences that the effects continued for some time after the end of the eclipse at sunset on the southeast coast of Africa. The amplitude (semi-range) of the short wave was, on the average, about one-half of that for the long wave. In the case of the magnetic declination, for example, the amplitude of the long wave for stations inside or near the totality-belt approximated, on the average, one minute of arc, which was equivalent to a horizontal deflecting force of about 0.01 per cent that of the average west-east component of the Earth's magnetism.

(3) A preliminary analysis of the magnetic effects at stations within the region of visibility, or in close proximity, showed that the effects in declination and horizontal intensity were similar to those produced by a north-end attracting focus located in the vicinity of the shadow cone. With the aid of the vertical-intensity effects it was found that the eclipse magnetic system was composed of an external and an internal system of forces.

At 12h. 30m.G.M.T., May 29, 1919, just before the maximum development of the eclipse system, the north end attracting focus of the external system was located east-southeast of the shadow cone, and that of the internal system was to the northward of the cone and approximately northward of the point where the Sun and the Moon were in the zenith. The momentarily increased magnetization of the Earth for stations near the belt of totality of 0.012 per cent at 12h. 30m. corresponded to the amount associated with about a six per cent decrease in solar radiation. Equally interesting results were disclosed at other times; invariably the positions of the foci of the disturbing forces could be related to the momentary position of the shadow-cone. The indications are that the complete analysis of the eclipse magnetic system will show that it has characteristics analogous to those exhibited by the systems causing the solar-diurnal and the lunar-diurnal variations of the Earth's magnetism.

839TH MEETING

The 839th meeting was held at the Cosmos Club, October 23, 1920. President SOSMAN presided and 25 persons were present. The program was as follows.

WILLIAM BOWIE: *The Pan-Pacific Scientific Congress.*

The speaker presented a paper on the recent scientific conference for the exploration of the Pacific which was held under the auspices of the Pan-Pacific Union in Honolulu, August 2–20, 1920. In the winter of 1919–20, a committee of the National Research Council, formed to consider the scientific exploration of the Pacific, held several meetings at which the necessary preliminary steps were taken and then the activities were transferred to Honolulu where a local committee of scientists perfected arrangements for the conference.

At the conference were representatives of the United States, Canada, Japan, New Zealand, Australia, the Philippine Islands and Hawaii.

The organization of the conference was described, and the general resolutions and those resolutions bearing on the geographic subjects which were adopted by the conference were explained in some detail. The scientific

work considered under geography consisted of geodesy, topography, physical oceanography, terrestrial magnetism, and meteorology

It was found that much work remains to be done in the Pacific in the various branches of science, and one of the purposes of the Congress was to present the evidence that would show that some central organization should be created that could assist and be a coordinating agency in scientific exploration in the Pacific region. It was the opinion of all those at the conference that the most urgent needs are in topographic mapping, including the shore line of the continents and islands, and oceanography, especially the configuration of the bottom of the ocean and the mapping of the direction and strength of the ocean currents. On this work, that is, topographic surveys and ocean charts, must be based much of the work in other lines of science.

The sessions of the conference were held at Honolulu, except that two general sessions, one on volcanology and one on seismology, were held at the volcano of Kilauea, which most of the delegates visited.

The speaker expressed appreciation of the hospitality and good will shown by the people of Honolulu to the members of the scientific congress.

It was stated that a publication will be issued by the Conference giving the resolutions and a brief history of the meeting This publication will probably be distributed in the very near future Later in the winter it is expected that one or more volumes will be published which will contain abstracts of minutes of the general sessions and of the meetings of the various sections, papers which were presented at Honolulu, and statements in regard to the various branches of science which are now in process of publication by the members of the conference. These later papers are expected to cover in more comprehensive form the problems of the scientific exploration of the Pacific region.

Discussion Messrs. SILSBEE, SOSMAN, FERNER, MAUCHLY, and HUMPHREYS discussed Mr. BOWIE's paper

P. V. WELLS: *The 1920 meeting of the British Association for the Advancement of Science.*

The meetings were held at Cardiff in the new public buildings which are grouped about a beautiful campus, leaving room at one end for the future Welsh Houses of Parliament. Sectional meetings opened on Tuesday morning (Aug. 24) with the presidential addresses, those of Prof. KARL PEARSON on Anthropology and of Prof. EDDINGTON on the Constitution of the Stars being particular features. The latter spoke of the radiative equilibrium in gaseous giant stars, their change in temperature from red to blue and final contraction to red dwarfs. Although the radiation within the giants is much like that of soft X-rays, their interior being at a temperature of millions of degrees, such stars are nearly heat tight. The radiation pressure prevents rapid shrinking and in fact overcomes gravitation in stars of much more than five times the mass of the sun, causing them to break up. ASTON's experiments leave no room for doubt that all the elements are built up of hydrogen and electrons, and the heat of the stars is accounted for by the mass radiated during their combination. "If indeed the sub-atomic energy in the stars is being freely used to maintain their great furnaces, it seems to bring a little nearer to fulfilment our dream of controlling this latent power for the well-being of the human race, or for its suicide."

In the evening President HERDMAN suggested a new Challenger expedition in his address on Oceanography. The next morning ASTON described his

epoch-making work on mass spectra proving atomic masses of all the elements to be whole numbers excepting hydrogen. Neon, chlorine, argon and many other elements are mixtures of isotopes of different masses but of the same atomic number (the number of positive charges on the nucleus which determines its atomic properties).

Sir ERNEST RUTHERFORD followed with a short description of his work on the disintegration of nitrogen and other gases into hydrogen particles moving with greater velocity than the bombarding α-particles themselves. Thus without doubt the hydrogen nucleus is the positive electron and stable groups of minute hydrogen particles, bound together by the much larger negative electrons, such as the helium nucleus (α-particle) form the nuclei of all the heavier atoms.

Especially interesting also were the remarkable discussion on the Origin of Spectra led by NICHOLSON, the note of Sir OLIVER LODGE on Relativity and the reply of Pres. EDDINGTON, the evening discourse of Sir RICHARD GLAZEBROOK on Aircraft and the vote of thanks moved by Dr. STRATTON of our Bureau of Standards. The wealth of things of interest in other branches of science, and the pleasant excursions of all sorts filled every moment of a busy and delightful week.

Discussion. The paper was discussed by Messrs SILSBEE and SOSMAN.

840TH MEETING

The 840th meeting was held at the Cosmos Club, November 6, 1920, with President SOSMAN in the chair and 32 persons present The following program was given

E. F. MUELLER and T. S. SLIGH, Jr *The hypsometer as a precision instrument* (presented by Mr. Mueller).

A very simple form of hypsometer, consisting of a nearly closed space into which steam from a boiler can be admitted, will serve to maintain a temperature in the steam space which differs at most by a very few hundredths of a degree from that corresponding to saturated steam at the prevailing atmospheric pressure. The well-known Rudberg or Regnault hypsometer is a very simple apparatus, and is capable of serving the requirements of all but the most precise thermometric measurements In the more elaborate designs which have been developed at the International Bureau and at the Reichsanstalt, the design has been largely influenced by such considerations as the desirability of being able to read mercurial thermometers in either a horizontal or a vertical position, of measuring accurately the difference between the pressure of the steam and atmospheric pressure, or of avoiding superheating of the steam, the last named feature being particularly emphasized. Apparently the question of purity of material, or the possibility of the steam being mixed with air, has received only incidental consideration.

In the design of a new portable hypsometer, advantage was taken of the difference in density of steam and air to insure rapid removal of air from the steam space by introducing the steam into this space at the top. This has the further advantage of rendering the temperature stable with no appreciable excess pressure in the steam space thus dispensing with the water manometer. Electric heating is used and the volume of the boiler is small, so that heating up is rapid. Two sheath heating coils are used which, connected in parallel, provide rapid heating, and connected in series suffice for regular operation.

Experiments with heat inputs from 125 to 640 watts indicate that such

variations produced no measurable effect in the temperature of the steam space, thus indicating the absence of both superheating and excess pressure in the steam space.

Extended experiments were made to determine the reasons for the fortuitous errors of about 0.005° usually observed in precise steam point determinations. Apparently such errors are due to irregular fluctuations in atmospheric pressure and to errors in measurement of barometric pressure, indicating that improvements in this respect will require the use of a closed system and better temperature control of the barometer.

The instrument described was exhibited and operated.

Discussion: The paper was discussed by Messrs. WHITE, TUCKERMAN, SOSMAN, HEYL, and BEALL.

T. S. SLIGH, JR.: *Thermostatics.*

In this paper it is shown that the degree of temperature regulation attainable in a thermostated bath depends upon the thermal and space relations of the various elements of the bath to an equal if not greater extent than upon the characteristics of the thermoregulator alone.

The three desirable characteristics of a thermoregulated bath are: steadiness of controlled temperature, constancy of controlled temperature, and range of regulation.

Steadiness is measured in terms of the periodic variations of the instantaneous temperatures of the working-space as the regulator operates. It is desirable that the amplitude of this variation be small and that the period be short.

Constancy is measured in terms of the variations of the time-average temperature of the working-space as measured over a complete cycle of operation of the regulator with variations of average rate of energy gain or loss from the bath.

Range may be measured in terms of the average energy input controlled by the regulator or its equivalent, the number of degrees of change in surroundings temperature for which the regulator is able to compensate.

It is shown by reference to the characteristic equations for thermostatic regulators as derived in the author's paper[1] that some gain is to be secured by increasing the sensitivity of the regulator but, in view of present practice, it seems that increased constancy, steadiness, and range can best be secured by reducing the over-all lag of the system. This lag is made up of the lag of the heater, the lag, or lapse, due to the time required for the water to circulate from the heater to the regulator bulb, and the lag of the regulator bulb. The lag of the heater may be made small by the use of a heating coil of small heat capacity and large dissipating surface. The stirring lapse may be made small by securing vigorous circulation and by placing the regulator bulb as close to the heater as is possible without the inclusion of a temperature gradient region between the regulator bulb and the working space. The regulator lag may be made small by the use of bulbs of large surface volume ratio and by securing a vigorous circulation of water past the bulb, thus reducing the thermal resistance of the bulb surface.

Great steadiness together with large range may be secured by the use of the oscillating contact regulator which is described in the paper referred to above.

[1] *Some characteristics of the Gouy thermoregulator.* Journ. Am. Chem Soc. Jan 1920

Great range together with constancy may be realized by the use of an auxiliary compensator which consists of a motor geared to the contact of the rheostat which controls the fixed heat supply to the bath. The direction of rotation of this motor is periodically reversed by a relay in such a manner that the fixed heating tends to be slowly increased or decreased during the parts of the cycle of operation of the regulator during which an increased or decreased supply of energy is required by the bath. Thus the fixed heating is increased or decreased as the bath requires an increased or decreased supply of energy over one or more complete cycles of operation of the regulator.

It is seen that this method of regulation requires only a *temporary* departure of the bath temperature from its normal value in order that a permanent change in the heating be effected, whereas without the auxiliary compensating mechanism the change in the heating persists *only* during the time that the bath temperature remains above or below normal.

The auxiliary compensator may be used in connection with the oscillating contact regulator to secure steadiness, constancy, and range to a high degree.

Discussion: This paper was discussed by Messrs. WHITE, BEALL, BREIT, TUCKERMAN, FERNER, WENNER, ADAMS, VAN DUSEN, HEYL, MUELLER, and SOSMAN.

S. J. MAUCHLY, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

MATTERS OF SCIENTIFIC INTEREST IN CONGRESS.[1]

The third session of the Sixty-sixth Congress convened on December 6, 1920.

Under a special rule adopted on December 14, the joint resolution (S.J. 191) to create a joint commission on reorganization of the administrative branch of the Federal Government was brought up for two hours' debate on that date and passed by the House, having already passed the Senate on May 10. The bill became Public Resolution No. 54 on December 30 without Executive approval The resolution requires the Committee to make a report in December, 1922. Mr SMOOT announced in February that the Committee would do the work personally and would not turn it over to the Bureau of Efficiency or any other governmental agency. Considerable shifting and rearrangement of the scientific bureaus has been predicted as a probable outcome of the reorganization movement.

The House Committee on Patents recommended on December 10 that the Nolan Patent Office bill (H.R. 11984) be sent to conference, but unanimous consent for such reference was refused in the House. Later, on December 14, the bill was sent to conference, and hearings were reopened by the conference committee in January. Section 9 of the bill, providing for the issuance of patents to Federal employees, continued to meet with opposition from commercial and industrial interests, but was retained in the bill. The House agreed to the conference report on February 16. Opposition developed in the Senate, and the bill did not reach final action before the end of the session on March 4.

The bill for Federal supervision of the nitrate plants (S. 3390), including provision for research on the fixation of nitrogen, was made the unfinished business in the Senate on December 15. After several debates and the adoption of a number of amendments, the bill passed the Senate on January 14. The House took no final action.

The American Society of Zoologists, at its annual meeting on December 28-30, 1920, passed resolutions protesting against the passage of that part of H R. 7785 (the scientific apparatus tariff bill) which abolishes the "duty-free privilege" to educational institutions Occasional protests against this feature of the bill have been discussed in current scientific and technical periodicals. This feature of the bill was brought up in a hearing on the Fordney emergency tariff bill before the House Committee on Ways and Means on February 14, and the sentiment of the Committee seemed to be strongly in favor of eliminating the duty-free privilege on chemical glassware, chemical porcelain and apparatus. The Fordney bill passed both houses, but was vetoed by the President.

[1] Preceding report This JOURNAL, 10: 423 1920

As for the special bill for a tariff on scientific supplies (H R 7785), although it had passed the House as long ago as August 2, 1919, the Senate took no final action and it lapsed with the adjournment on March 4

A bill "to fix the metric system of weights and measures as the single standard for weights and measures" was introduced in the House by Mr BRITTEN on December 29 (H.R. 15420), and in the Senate by Mr FRELINGHUYSEN (by request) on December 18 (S. 4675) The bills are said to have been "fathered" by the World Trade Club of San Francisco They were referred to the respective weights and measures committees and no further action was taken.

The Smith-Towner bill to create a Department of Education (S. 1017 and H.R. 7) after lying dormant through nearly the entire life of the Congress, was reported in the House on January 17 and in Senate on March 1, but progressed no further

A step toward the erection of the proposed building for the National Academy of Sciences was taken in the introduction of S 4645, "to authorize the Commissioners of the District of Columbia to close upper Water Street between 21st and 22d Streets, NW." The bill passed the Senate on February 24, but advanced no further.

With the adjournment of the Sixty-sixth Congress at noon on March 4, various other bills and resolutions which are of interest to scientists and which have been commented upon in this section of the JOURNAL either perished in committees or at the intermediate stage of progress last noted in these columns.

NOTES

The twenty-third edition of the Directory of the Washington Academy of Sciences and its affiliated societies (the "Red Book")appeared early in March. This edition contains 2779 names and data concerning 35 societies.

The following lectures have been presented before the Physics Club of the Bureau of Standards during the present season November 1, 1920, W J HUMPHREYS *The roaring mountain and associated phenomena* November 15, J. C. KARCHER. *X-ray spectroscopy, with special reference to X-ray spectra in vacuo.* November 29, R. C. TOLMAN *The rate of chemical reaction* December 13, F C. BROWN. *Propagated light sensitiveness of selenium* January 10, 1921, I. G. PRIEST *Chicago meeting of the Optical Society of America,* E A. ECKHARDT *Chicago meeting of the American Physical Society.* January 24, R. S. WOODWARD. *The doctrine of relativity and Einstein's theory of gravitation.* February 7, P. V. WELLS. *Statistics, or the theory of sampling, and its relation to the physical sciences.* March 7 and 21, P. D. FOOTE *Modern developments of the Bohr theory of atomic structure*

The following-named officers were elected at the annual meeting of the Scientific-Technical Section of Federal Employees Union No. 2 in December *President:* J. FRANKLIN MEYER, Bureau of Standards, *Vice-President* GEO. A. HILL, U. S. Naval Observatory; and *Secretary-Treasurer* C. T. JARVIS, Bureau of Education. At the meeting of the Board of Delegates on February 24, D. R. GLASS, Public Health Service, was elected *Secretary-Treasurer,* to succeed C. T. Jarvis, resigned. The following were named members of the *Executive Committee:* V. K. CHESNUT, Bureau of Chemistry, Miss EUNICE OBERLY, Library, Department of Agriculture; W. C. THURBER, Patent Office; and W. I. SWANTON, Reclamation Service.

The section of vertebrate paleontology of the National Museum has just

received, from the Upper Cretaceous deposits along the Red Deer River of Alberta, Canada, an exhibition specimen of a skull of the crested dinosaur *Stephanosaurus*, a unique genus heretofore unrepresented in the collections. *Stephanosaurus* is remarkable on account of the development on the top of the skull of a high thin bony crest resembling that of the living Cassowary.

Dr. D. BORODIN, Russian economic entomologist, has been visiting Washington and has been looking up Russian entomological literature in the libraries of this city. Before the revolution Dr. Borodin was director of the Agricultural Experiment Station at Poltawa, in southern Russia.

The honorary degree of Doctor of Sciences was conferred upon Messrs. FREDERICK V. COVILLE, botanist in the Bureau of Plant Industry, U. S. Department of Agriculture, and FRANK SPRINGER, paleontologist in the U. S. National Museum, at the centenary graduation exercises of George Washington University on February 22.

Mr. C. R. DELONG has been appointed chief of the chemical division of the U. S. Tariff Commission, succeeding Dr. GRINNELL JONES, who has returned to Harvard University but retains a connection with the Commission in an advisory capacity. The other members of the chemical staff of the Commission are Messrs. S. D KIRKPATRICK, W. N. WATSON, and A. R. WILLIS.

Dr. ALFRED DOOLITTLE, professor of mathematics and instructor in astronomy at the Catholic University since 1898, died on February 23, 1921.

Dr. PENTTI ESKOLA, of the Geological Survey Commission of Finland, is engaged in petrologic research at the Geophysical Laboratory of the Carnegie Institution of Washington.

Dr. MAURICE C. HALL, of the Bureau of Animal Industry, has been elected secretary of the Washington Alumni Chapter of the Society of the Sigma Xi The Society plans to have a series of informal inspection trips to the scientific institutions of the city

Dr. L. I. SHAW, of the Bureau of Mines, has been elected treasurer of the Chemical Society, succeeding the late FREDERIC P. DEWEY.

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BOTANY.—*Synopsis of the genus* Datura.[1] William E. Safford, Bureau of Plant Industry.

A critical study of the genus *Datura* has revealed great confusion in botanical literature in connection with the specific identity, as well as the origin, of some of the most common species.[2] Some authors, for example, call a certain species endemic in Mexico and northern South America *Datura metel;* but the true *Datura metel*, described by Linnaeus in the first edition of his *Species Plantarum*, is a species based upon the Asiatic metel nut, or "jouz-methel," which was used as a narcotic by the Arabs, Persians, and Hindoos long before the discovery of America, and was described by Avicenna in the eleventh century. Forms of this species, differing from the type in color and in the reduplication of the corolla, have been set apart as a distinct species under the name *Datura fastuosa*, while the white-flowered type itself was rechristened *Datura alba* Much of the confusion is due to the treatment which this genus received at the hands of Dunal in the first part of volume thirteen of De Candolle's *Prodromus* (1852), in which the name *Datura metel* was transferred from the Asiatic plant above mentioned to an American plant described in 1768 by Miller under the name *Datura innoxia*.

Conflicting statements regarding the origin of the well known Jamestown weed (*Datura stramonium* L.) are frequently encountered.[3] Certain authors declare it to be of Asiatic origin, although Linnaeus in describing it states that it is American Others assign the typical form, with green stem and white flowers, to Asia, and the purple-stemmed lavender-flowered form, commonly called *Datura tatula*, to America. Still others have separated a variety with smooth capsules from the typical prickly-fruited form under the name *Datura inermis* Observations on growing plants show that both the white-flowered and purple-flowered forms may bear either smooth or prickly capsules, in some cases even on the same plant. Experiments in cross-breeding have demonstrated that of the antagonistic color characters, the

[1] Received March 14, 1921.

[2] See Hemsley, Biol. Centr Am Bot 2: 427. 1882

[3] See Robinson & Fernald, Gray's Manual ed 7 717. 1908 Britton & Brown, Illustr. Fl. ed. 2. 3: 169. 1913.

purple is dominant and the white-flowered form recessive, and of the contrasted capsule forms the prickly one is dominant and the unarmed (*inermis*) recessive; so that at one end of the series we have the so-called *Datura tatula* and at the other the white-flowered "*Datura inermis*." This is discussed in the author's forth-coming paper, "*Datura, an inviting genus for the study of heredity*," to be published in the Journal of Heredity.

The tree daturas of South America have been segregated as a distinct genus under the name *Brugmánsia*, chiefly on the score that they have fleshy spineless indehiscent fruits devoid of a persistent expanded calyx base; but the section *Ceratocaulis* is characterized by similar fruits and may be regarded as connecting the tree daturas with the section *Dutra*, in which the capsules are irregularly dehiscent and inclined or nodding, quite unlike the erect valvate capsules of the section *Stramonium*.

A study of the tree daturas shows that more than one species has been included under certain specific names. Thus *Datura arborea* of Ruiz and Pavon and *Brugmansia arborea* of Lagerheim are specifically distinct from the true *Datura arborea* L., based upon Père Feuillée's *Stramonioides arboreum*, and the pubescent orange-flowered *huantuc* of Ecuador, with sinuate woolly leaves, is also quite distinct from the typical *Datura sanguinea* of Ruiz and Pavon, with which it has been confused.

The following systematic synopsis is part of a paper submitted by the writer as a thesis for the degree of Doctor of Philosophy at George Washington University The remainder of the paper, illustrated by numerous photographs of living plants, will appear in the forthcoming Year Book of the Smithsonian Institution.

DESCRIPTION OF THE GENUS

The genus *Datura*, established by Linnaeus (Gen. no. 246) with *Datura stramonium* as its type, belongs to the family Solanaceae and to the tribe Datureae, which includes also the closely allied genus *Solandra* of tropical and subtropical America It may be characterized as follows.

Calyx long-tubular, herbaceous, appressed to the corolla tube or inflated, toothed at the apex or spathe-like and split down the side, in certain groups circumscissile at the base, leaving a disk which enlarges like a shield or cup subtending the fruit, in another group either disappearing entirely or persisting like a husk which covers the lower part of the fruit. Corolla funnel-shaped or trumpet-shaped, in certain species suggesting the corolla of a *Convolvulus*, the tube usually long and slender, the limb plicate and either 5-lobed with the lobes separated by sinuses, or circular or 10-angled, with the margin between the 5 teeth entire or obtusely angled, the angles sometimes cuspidate giving to the expanded limb the form of a 10-pointed star. Stamens

5; perfect, adnate to the inner surface of the tube at the middle or near the base, slightly or not at all exserted, the filaments slender and thread-like, the anthers linear, free or rarely cohering, the anther-cells parallel, longitudinally dehiscent. Ovary 2-celled (sometimes falsely 4-celled); style thread-like; stigma 2-lobed. Fruit a dehiscent 4-valved capsule or a more or less fleshy berry, the surface spiny or smooth. Seeds numerous, compressed laterally, discoid or imperfectly ear-shaped, sometimes with a cork-like covering; embryo curved, cotyledons semiterete.—Herbs, shrubs, or small trees, glabrous, farinaceous, or pubescent. Leaves broad, thin, entire, angulate, or coarsely sinuate-dentate. Flowers solitary, erect or drooping, sometimes very large.

KEY TO THE SECTIONS

Flowers erect; calyx circumscissile near the base, the base persistent and expanding like a frill, shield or cup.
  Fruit an erect dehiscent 4-valved capsule. I. *Stramonium.*
  Fruit inclined or nodding, not dehiscing regularly.
    Plants terrestrial; pericarp spiny or tuberculate, with an expanded, frilled or shield-like calyx-base. II. *Dutra.*
    Plants aquatic or marsh-loving; pericarp smooth, with small discoid or cup-like calyx-base. III. *Ceratocaulis.*
Flowers pendulous; calyx not circumscissile, either falling off entirely or persisting like a husk appressed to the fruit, the latter unarmed and indehiscent, spheroid, lemon-shaped, fusiform, or elongated and terete. IV. *Brugmansia.*

SECTION I. STRAMONIUM Gaertner.

Flowers erect, calyx tube circumscissile near the base, falling off together with the corolla, the base persisting and expanding into a disc, the margin of which is at length turned downward and frilled. Corolla distinctly 5-lobed, the lobes separated by emarginate sinuses. Fruit (Fig. 1, A) an erect regularly dehiscent 4-valved capsule, armed with rigid spines or unarmed.

Type of the section, *Datura stramonium* L.

KEY TO THE SPECIES

Capsule normally armed with subequal spines, these sometimes much abreviated or wanting; flowers white or lavender-colored. 1. *D. stramonium.*
Capsules armed with strongly unequal spines, the upper ones longer and stouter.
  Leaves ovate or oblong; sinuate-toothed or angled. 2. *D. ferox.*
  Leaves pinnately lobed.
    Branches, petioles, and calyx downy or woolly. 3. *D. quercifolia.*
    Branches, petioles, and calyx villous or hairy. 4. *D. villosa.*

1. Datura stramonium L. Sp. Pl. 1: 179. 1753.

Datura tatula L. Sp. Pl. ed 2. 1: 256. 1762.
Datura inermis Jacq. Hort. Vindob. 3: 44. *pl. 82.* 1776.

TYPE LOCALITY: "Habitat in America, nunc vulgaris per Europem."

RANGE: Throughout eastern North America, Central America, and South America; introduced at a very early date into the warmer regions of Europe, Asia, and Africa.

A common weed in waste places, used by the Algonquin Indians as a narcotic.[4] The purple-flowered variety is commonly known under the name *D. tatula*, the form with unarmed fruits as *D. inermis*.

[4] For the origin of its common name, Jamestown, or Jimson, weed, see BEVERLEY, Hist. Virginia, book 2, p 24. 1705.

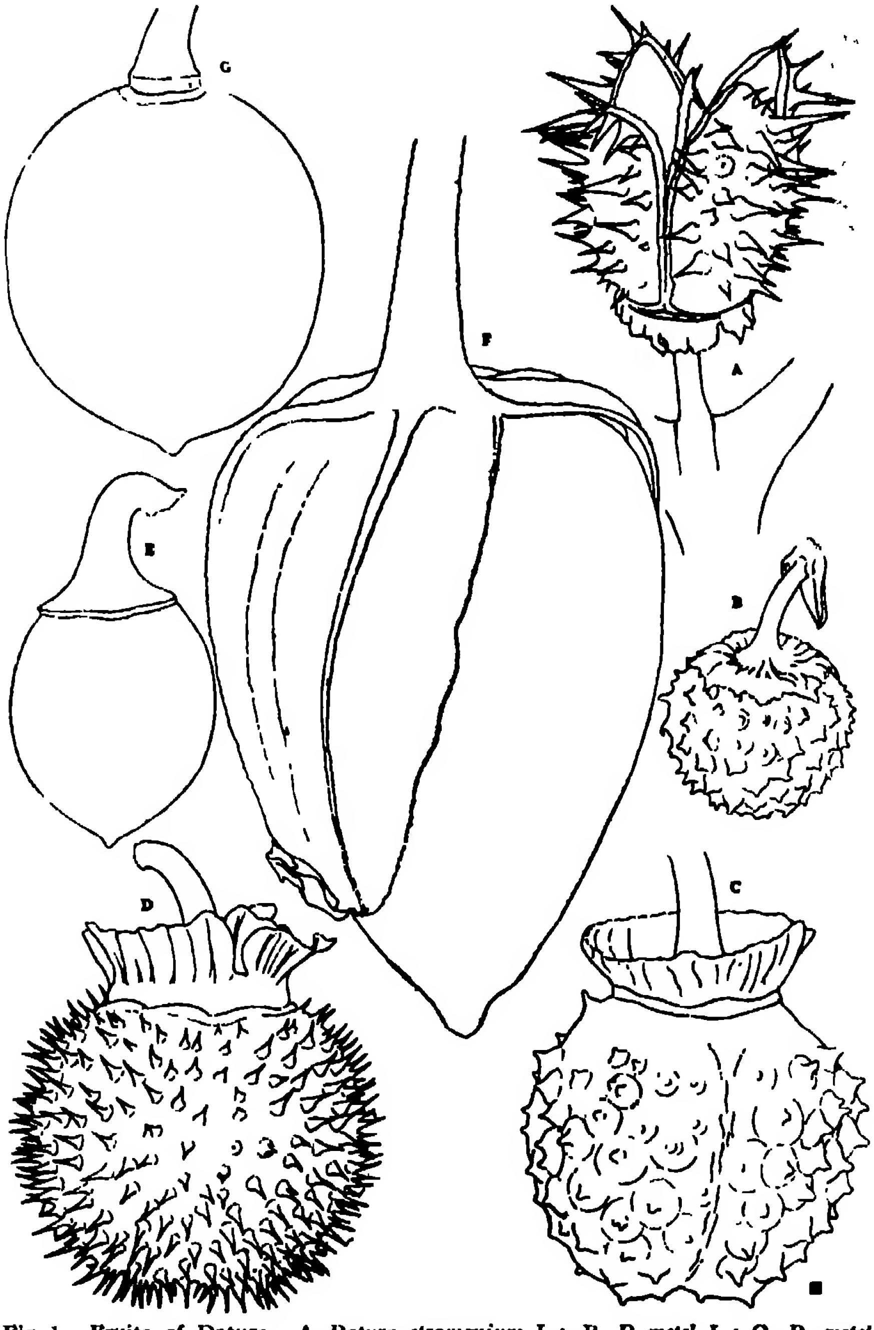

Fig 1. Fruits of Datura A, *Datura stramonium* L.; B, *D. metel* L; C, *D metel fastuosa* L; D, *D meteloides* Dunal, E, *D. ceratocaula* Jacq.; F, *D. sanguinea* R. & P, G, *D. arborea* L. All natural size

2. **Datura ferox** L. Amoen. Acad. 3: 403. 1764

TYPE LOCALITY. "Habitat in China."

RANGE: Warmer regions of China; introduced into Sicily and Spain.

A weed growing in waste places, very similar to *D. stramonium*, with the pericarp bearing 4 very large stout spines at the apex. Called in Spain *Estramonio de la China*.

3. **Datura quercifolia** H. B. K. Nov. Gen. & Sp. 3: 7. 1818.

TYPE LOCALITY "Crescit locis temperatis Regni Mexicani prope Zelaya et Molino de Saravia, alt. 930 hex."

RANGE: Texas to Arizona and Mexico.

A common weed along the banks of ditches. Leaves pinnately lobed, pericarps armed with large rigid ascending spines.

4. **Datura villosa** Fernald, Proc. Amer. Acad. 35: 571. 1900.

TYPE LOCALITY Bolaños, Jalisco, Mexico.

RANGE: Jalisco and San Luis Potosi, Mexico, at altitudes of 1800 to 2500 meters.

A weed growing in waste places, related to *D. quercifolia*, with which it has been confused.

SECTION II. DUTRA Bernhardi

Flowers erect; corolla trumpet-shaped or funnel-shaped, the expanded limb either 5-lobed or 10-angled; calyx-tube circumscissile, falling off with the corolla, the persistent base at length expanding into a membranous frill or cup, either reflexed or appressed to the fruit Fruit (Fig. 1, B, C, D) borne on an inclined or nodding peduncle, not valvate but at length breaking open irregularly, its surface tuberculate or spiny, the spines sometimes flexible and not pungent, in some species pubescent.

Type of the section, *Datura metel* L.

KEY TO THE SPECIES

Fruiting peduncle usually curved to one side, sometimes cernuous; pericarp tuberculate or armed with short spines; plant glabrous or nearly so, corolla white or colored, normally 5-lobed, in cultivation often double or triple, the outer corolla 5-lobed or 6-lobed, the inner corollas 5 10-lobed, the lobes separated by acute sinuses.—An Asiatic species including several well-marked varieties 5. *D. metel*.

Fruiting peduncle abruptly nodding, pericarp armed with spines; plants pubescent or pruinose, corolla white or tinged with lavender or purple, the expanded limb 10-angled.—Plants of American origin.

Flowers more than 6 cm. long.

Corolla funnel-shaped, white or tinged with purple or lavender; pericarp armed with weak spines, seeds light brown.

Plant softly pubescent; corolla white, 10-toothed. 6. *D. innoxia*.

Plant glaucescent, corolla usually suffused with pale lavender, 5-toothed. 7. *D. meteloides*.

Corolla trumpet-shaped with broadly flaring 10-toothed limb, white with purple or violet throat; pericarp armed with stout spines, seeds black. 8. *D. discolor*

Flowers not exceeding 6 cm. in length; corolla white; pericarp armed with short slender prickles, which together with the whole surface of the capsule are finely pubescent. 9. *D. pruinosa*.

5. **Datura metel** L. Sp Pl. 1: 179. 1753. FIG. 1, B, C.
Datura fastuosa L. Syst. ed. 10. 2: 932. 1759.
Datura alba Nees, Trans. Linn. Soc. 17: 73. 1834.
TYPE LOCALITY: "Habitat in Asia, Africa."
RANGE: Tropical and subtropical Asia and Africa; now widely cultivated throughout the warmer regions of both hemispheres.

In the first edition of the *Species Plantarum* Linnaeus briefly described this species as "Datura pericarpiis spinosis nutantibus, globosis," and cited his earlier description of it in the *Hortus Cliffortianus* (1737). In the latter work it is identified with the "*Solanum pomo spinoso rotundo longo flore*" of Bauhin (1623), "*Stramonia multis dicta sive pomum spinosum*" of Bauhin's *Historia* (1651); the "hummatu" of Rheede's *Hortus Malabaricus* (2: 47. *pl 28.* 1678); "*Stramonia seu Datura, pomo spinoso rotundo, longe flore*" of Hermann (1687); and "*Stramonium fructo spinoso rotundo, flore albo simplici,*" of Tournefort and Boerhaave. The range is cited as "Crescit in Oriente, in Malabaria, Aegyptio, etc."

In the second edition of the *Species Plantarum* (1762) Linnaeus adds to his citations Rumph's *Herbarium Amboinense* (5: *pl. 87* 1755), in which the simple-flowered *Datura metel* is figured, accompanied by the double-flowered form called *Datura fastuosa* by Linnaeus in the tenth edition of his Systema (1759). He also adds to his description "foliis cordatis subintegris pubescentibus," but this is not applicable to the true *Datura metel.* This interpolation, if it can be so called, is responsible for much of the resulting confusion of this and allied species. Dunal, in his description of *Datura metel* in DeCandolle's *Prodromus,* does not cite the original description of Linnaeus's *Datura metel* in the first edition of the *Species Plantarum,* but that of the second edition, in which the plant is erroneously described as pubescent. In the first edition Linnaeus takes great care to identify his *Datura metel* with the "metel nut" of Asia. Dunal, on the other hand, amends the original description of the species, and refers to it a plant collected by Berlandier in the vicinity of Victoria, in eastern Mexico, undoubtedly distinct from the true *Datura metel* L., but identical with the pubescent white-flowered *Datura innoxia* Miller, described from a type also collected in eastern Mexico. The latter species can-

Fig 2. *Datura metel* L. Illustration of J. Bauhinius under the name "Stramonia multis dicta sive Pomum spinosum," Hist. Pl 3: 624 1651, cited by Linnaeus in his Hortus Cliffortianus.

not possibly be identified with *Datura alba* Nees, as suggested by Dunal, as that species is the typical white-flowered form of *Datura metel* L.; and *Datura innoxia*, described below, has its "stalks, branches, and leaves, covered with soft hairs."

It is interesting to note that in the *Hortus Cliffortianus* the first two synonyms cited identify Linnaeus's *Datura metel* with the *Stramonia*, or *Pomum spinosum*, described and figured by Johannes Bauhin, and clearly identified by him with the *Stramonia* of Fuchsius and the *Nux methel* of Avicenna. Bauhin's figures agree with that of Fuchsius (1542) in the form and surface of the fruit, which bears very short and thick spines, not subulate or needle-like prickles; indeed his second figure, here reproduced, is a reduced copy of Fuchsius's.[5]

It is surprising that C. B. Clarke,[6] in Hooker's *Flora of British India*, not only ignores Linnaeus's references to the authorities above mentioned in connection with *Datura metel*, but transfers this specific name from the metel-nut or *dhatura* of India to a plant of American origin, citing as an illustration of the species, not the figures of Fuchsius, Bauhinius, or Rumphius, but an illustration in Curtis's *Botanical Magazine* (plate 1440) which on investigation proves to be the drawing of a plant grown in London under the name *Datura innoxia*, from seeds of American origin, identical with the Vera Cruz plant described by Miller in 1768 under the latter name. The specific identity of the white and purple forms of the Asiatic *Datura metel* L. is recognized by the best authorities on East Indian botany, but that the perfectly valid name *Datura metel* should be discarded for the varietal name *D. fastuosa*, as by Trimen,[7] is inexcusable.

It was this Asiatic plant, called in India *Dhatura*, or *Dutra*, that gave to the genus its name. True to his principle of not adopting a barbarous word for a generic name, Linnaeus latinized the East Indian *Dhatura* or *Dutra;* modifying it, however, to the form *Datura*, and commending the name by the following pun: "Daturae, licet originis sit peregrinae, vocabulum persistere valet, cum a latina derivari potest; dantur et *daturae* forte in Indiis posthac semina a lascivis foeminis maritis inertibus "[8]

6. **Datura innoxia** Mill Gard. Dict. ed 8. *Datura* no. 5. 1768.

Datura metel Sims, Curtis's Bot. Mag. 35: *pl.* 1440 1812. Not *D. metel* L.
• *D. guayaquilensis* H. B. K. Nov. Gen & Sp. 3: 8. 1818.
D. metel Dunal in DC. Prodr. 13[1]: 543. 1852.

[5] Compare the second figure of J. BAUHINIUS, Hist. Pl. 3: 624 (1651), with the colored engraving in FUCHSIUS, Hist. Stirp 690 (1542), which is clearly the true *nux methal*, or East Indian *dhatura*, and is quite distinct from the American plant erroneously called *Datura metel* in modern text-books.

[6] HOOKER, Fl. Br Ind 4: 243. 1885.

[7] Handb Fl Ceyl 3: 238. 1895.

[8] Hort. Cliffort. 56. 1737.

TYPE LOCALITY. "The fifth sort grows naturally at Vera Cruz, from whence I received the seeds."

RANGE Mexico to South America and the West Indies. Introduced at an early date into the Canary Islands, North Africa, and India.

This "downy thorn-apple," as it was called by Sims, has been frequently confused with the Old World *Datura metel* of Linnaeus, from which it may be readily distinguished by its 10-angled corolla and the soft pubescence of its foliage and young branches. It was characterized by Miller in 1768 as follows "Datura (*Inoxia*) pericarpiis spinosis inoxiis ovatis propendentibus foliis cordatis pubescentibus." A plant grown from seeds from Vera Cruz was described by him as follows. "This rises with a purplish stem three to four feet high, dividing into several strong branches, garnished with oblong heart-shaped leaves. The stalks, branches, and leaves of this sort are covered with soft hairs, the flowers come out at the division of the stalks and branches, standing erect; they are large, white, and are succeeded by oval fruit covered with long soft innocent spines, opening into four cells, which are full of brown seeds."

The above description accords with that of the Mexican *Nacascul*, or *Toloatzin*, the leaves of which were characterized by Hernandez[9] as "mollia, pinguia, et hirsuta." It was figured by Sims in 1812, as above cited, from a plant grown in London from seeds of American origin Sims referred it to Linnaeus's *Datura metel*, but he was not at all confident that he was correct in doing so. "Our plant was said to be raised from seeds sent from Surinam," he says, "and we think it doubtful whether it be the same species as the East Indian plant, which grows to a much larger size and is not described as being so pubescent. . . . We were favored with the plant from which our drawing was taken, by Mr. Salisbury, proprietor of the botanic garden in Sloane Street, under the name of *Datura innoxia* of Miller, and it is not unlikely but it may be the same as the one described by him, which he raised from seeds received from Vera Cruz."

Notwithstanding the uncertainty thus expressed by the author, the name *Datura metel* was subsequently transferred by several botanists from the Asiatic metel-nut, upon which Linnaeus had bestowed it, to this American "downy thorn-apple," a species which may be readily distinguished from the true *Datura metel* L not only by its soft pubescent but by its 10-toothed corollas. It seems strange that even in Hooker's *Flora of British India* the name *Datura metel* is applied to this introduced plant of American origin, while the true *Datura metel* is called by a varietal name *D. fastuosa*, with *D. alba* Nees given as the name of its typical form, in which the corolla is white and single.

7. **Datura meteloides** Dunal. in DC. Prodr. 13^1: 544. 1852. FIG. 1, D.

Datura wrightii Hort. ex Regel, Gartenfl. *pl. 260.* 1859.

TYPE LOCALITY: "In calidis Novae Hispaniae regionibus."

RANGE· Western Texas to California, Mexico, and northern South America.

[9] HERNANDEZ, Res. Med. Nov Hisp. Thesaurus, 113. 1651.

A handsome plant bearing large heavily scented flowers with a decagonal corolla limb, white, usually suffused with lavender or pale violet. Stems and foliage glaucescent. Fruit nodding, indehiscent (Fig. 1 D).

This species is held sacred by several Indian tribes of the southwestern United States. It is without doubt the Ololiuhqui of the Aztecs, who used it ceremonially and medicinally very much after the same manner as it is still used by our own Indians in New Mexico, Arizona, and California. An account of the Zuñi myth associated with it and its use by the Luiseño Indians of southern California in initiating their youths to manhood will appear in the paper by the writer to be published in the forthcoming Annual Report of the Smithsonian Institution.

8. **Datura discolor** Bernh. Trommed. N. Journ. Pharm. **26**: 149. 1838

Datura thomasii Torr. Pacif. R. R. Rep. **5**: 362. 1856.

TYPE LOCALITY: "Habitat in India occidentali."

RANGE: West Indies, Mexico, and the southwestern United States

A plant somewhat resembling *D. meteloides*, but with the corolla 10-toothed and trumpet-shaped instead of funnel-shaped, and usually stained with purple at the throat. It is easily distinguished from the former, with which it is not infrequently associated, by its smaller flower, black seeds, and the long stout spines with which its smaller nodding fruit is armed.

9. **Datura pruinosa** Greenm. Proc. Amer. Acad. **33**: 486. 1898.

TYPE LOCALITY: Cuicatlan, Oaxaca, Mexico.

RANGE: State of Oaxaca, altitude 550 to 1550 meters.

This plant may readily be distinguished from its allies "by the small flowers and the fine pruinose pubescence of the young leaves and the tips of the young branches."

SECTION III. CERATOCAULIS Spach.

Fruit (FIG. 1, E) a pendent or abruptly deflexed smooth berry, subtended by the enlarged persistent base of the calyx; flowers erect, trumpet-shaped, the calyx spathe-like and split down one side, the corolla tube long and narrow, the limb 10-toothed; stamens exserted, subequal. This section was segregated from the rest of the Daturas by Rafinesque, under the name *Apemon*.

KEY TO THE SPECIES

A single species.—Leaves pinnately lobed, farinose beneath; corollas large, white stained with blue. An aquatic plant of Mexico and Central America. 10. *D ceratocaula*.

10. **Datura ceratocaula** Ort. Dec. 11. 1798. FIG. 1, E.

Datura macrocaulis Roth, Neue Beitr. 159. 1802.

Apemon crassicaule Raf. Fl. Tell. **2**: 11. 1836.

Datura sinuata Sessé & Moc. Pl. Nov. Hisp. ed. 2. 24. 1893.

TYPE LOCALITY: "Prope urbem Mexici et in insulâ Cuba.

RANGE: States of Mexico, Querétaro, and Oaxaca, usually in shallow water.

A fleshy plant with thick dichotomous stem and horn-like branches, the narcotic "Torna-loco" ("Maddening-plant") of the Mexican marshes. It

was one of the plants called "Atlinan" by the Aztecs, who called it "Sister of the Ololiuhqui" and invoked its spirit in treating certain diseases.[10]

SECTION IV. BRUGMANSIA (Persoon).

Flowers pendulous, very large, calyx not circumscissile near the base, either falling off entirely or persisting as a husk-like envelope about the base of the fruit, fruit unarmed, smooth, spheroid, oblong, fusiform, or linear and terete. Type of the section, *Datura candida* (Persoon).

KEY TO THE SPECIES

Calyx spathe-like, terminating in a point.
 Flower white
  Corolla more than 20 cm. long; margin of limb between the teeth entire or rounded — 11. *D. candida*.
  Corolla not exceeding 17 cm. in length; margin of limb between the teeth cordate or emarginate.
   Calyx tapering into a horn-like point — 12. *D. cornigera*.
   Calyx without a horn-like apex. — 13. *D. arborea*
 Flower colored.
  Corolla large, more than 25 cm. long.
   Peduncle, petioles and young branches glabrous, corolla at length turning red. — 14. *D. versicolor*
   Peduncle, calyx, nerves of the corolla, and margins of corolla teeth clothed with soft hairs, corolla pink. — 15. *D. mollis*
  Corolla small, not exceeding 15 cm. in length, red. — 16 *D. rubella*
Calyx toothed at the apex.
 Flower white.
  Anthers coherent, corolla teeth short, about 1 to 2 cm long. — 17. *D. suaveolens*.
  Anthers distinct, corolla teeth 2 to 5 cm long.
   Fruit ovoid. — 18 *D. affinis*.
   Fruit long and slender.
    Leaves lanceolate to ovate-lanceolate, entire — 19. *D. dolichocarpa*
    Leaves linear-oblong, sinuate-repand. — 20 *D longifolia*.
 Flower colored.
  Calyx deciduous, more than half the length of the corolla
   Apex 5-toothed, fruit narrowly ovoid, beaked — 21. *D. aurea*.
   Apex 2-toothed, fruit elongate-ovoid, not beaked — 22 *D. pittieri*
  Calyx persistent, less than half the length of the corolla.
   Uppermost leaves entire or repand, puberulent. — 23. *D. sanguinea*
   Uppermost leaves angular-toothed, densely tomentose. — 24. *D. rosei*.

11. **Datura candida** (Pers.) Safford.

Datura arborea Ruiz & Pavon, Fl. Peruv. 2: 15. *pl. 127*. 1799. Not *D. arborea* L. 1753.

Brugmansia candida Pers. Syn. Pl. 1: 216. 1805.

TYPE LOCALITY: "Habitat in Peruviae hortis, versuris et septis, passim ad Cercado, Chancay, et Huanuci Provincias"

RANGE: Known only in cultivation; now widely spread in tropical and subtropical countries.

[10] JACINTO DE LA SERNA, in Documentos Ined para la Hist de España 104: 159–160

This is the large white-flowered Floripondio of the gardens of Northern Chile, Peru, Honduras, Guatemala, and Mexico. It was figured by Ruiz and Pavon, as above cited, under the name *Datura arborea*, but is quite distinct specifically from Père Feuillée's plant, which was the type of Linnaeus's *D arborea*. It is also distinct from Lagerheim's *Brugmansia arborea* (see beyond, no. 18), the calyx of which is 2- to 5-toothed, and the peduncle glabrous The specimens in the National Herbarium, like that figured by Ruiz and Pavon, are characterized by a relatively short, loose, pointed, spathe-like calyx. In the illustration of the fruit of the latter the calyx is represented as persistent, but this may possibly be an error.

12. **Datura cornigera** Hook. Curtis's Bot Mag. *pl. 4252.* 1846.
TYPE LOCALITY: Described from a cultivated plant of unknown origin.
RANGE: According to Hemsley, it occurs in the Valley of Mexico.

Hooker points out the characters of this plant, which distinguish it from closely allied species, and adds. "It is not the *Datura arborea* of Linnaeus and of Feuillée, plate 46; nor the *Datura arborea* of Ruiz and Pavon's plate 128, which has a much larger flower, with the calyx deeply cleft but appressed to the corolla. In the present species it runs out at the apex into a long, subulate spreading point"

13. **Datura arborea** L Sp Pl. 1: 179. 1753. FIG 1, G
TYPE LOCALITY "Habitat in Peru."
RANGE Peruvian Andes Now widely cultivated in tropical and subtropical countries.

This species was based by Linnaeus on the *Stramonioides arboreum* described and figured by Père Feuillée in his *Journal des Observations Physiques, Mathematiques et Botaniques*, 1714, and is quite distinct from *D. arborea* Ruiz & Pavon The flowers of the type were about 15 cm. (6 inches) long, with the corolla limb distinctly 5-lobed, the lobes separated by distinct sinuses or notches, the peduncle clothed with whitish velvety pubescence, and the broadly ovoid fruit quite devoid of calyx, about 6.25 cm long and 5 6 cm. in diameter.

14 **Datura versicolor** (Lagerh.) Safford.
Brugmansia versicolor Lagerh. Bot. Jahrb. Engl. **20:** 666. 1895.
TYPE LOCALITY. "Habitat in Aequatoria, ad 'Balsapamba' in regions tropica provinciae Los Rios."
RANGE. Known only from the type locality.

A beautiful species with fragrant flowers, the corolla of which, at first white, gradually turns to a brick red color. It is closely allied to *D. dolichocarpa*, but differs from it in the form of its spindle-shaped fruit, which terminates in a very long slender point. The petioles and peduncles are quite glabrous.

15 **Datura mollis** Safford, sp. nov
Shrub or small tree, with pubescent, ovate-lanceolate, entire or remotely

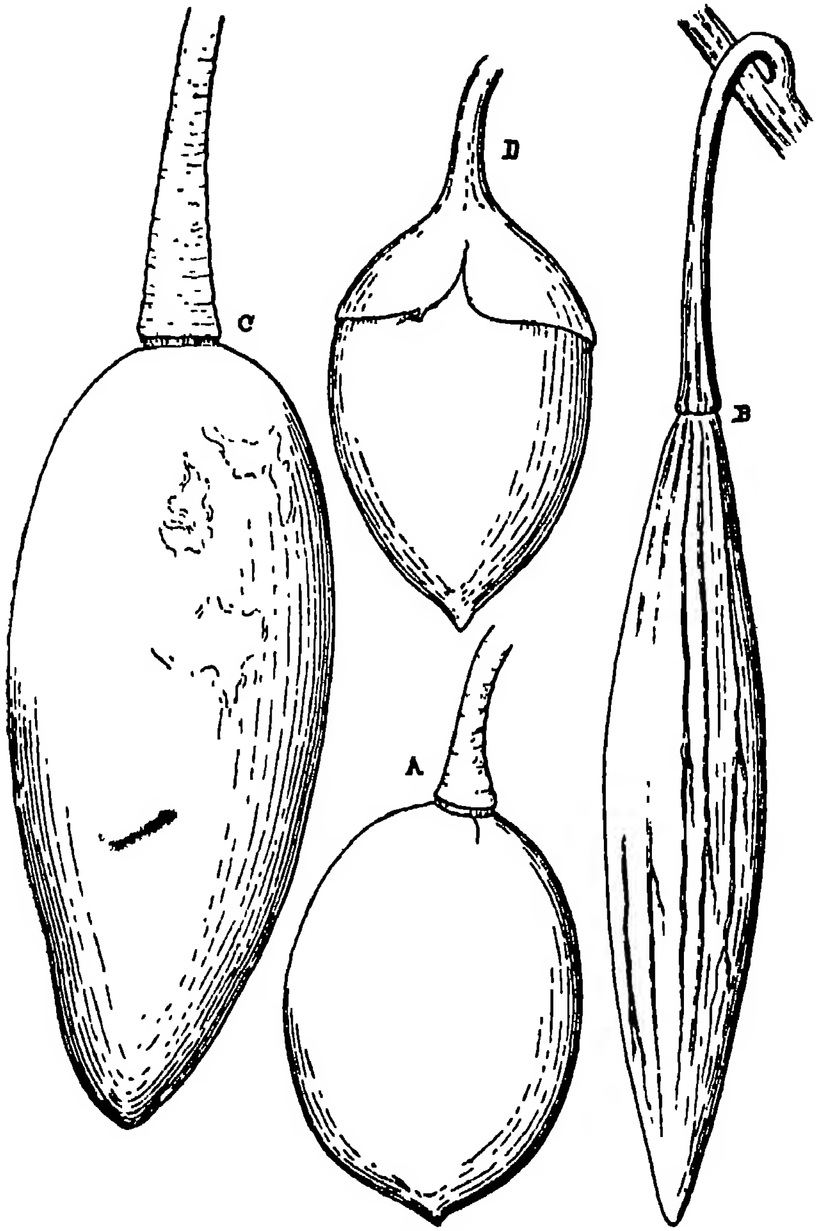

Fig 3. Fruits of South American Tree Daturas belonging to the section *Brugmansia* A, *Datura rubella* Safford; B, *D. suaveolens* H. & B.; C, *D. pittieri* Safford; D, *D. rosei* Safford All × $^1/_4$.

toothed leaves, 22 cm. long, and 10.5 cm. wide; calyx spathe-like, 19 to 20 cm. long, obtusely pointed at apex, somewhat inflated, densely clothed, like the peduncle, with soft spreading hairs, corolla 25 or 26 cm. long, light pink, resembling that of *D. candida* in form, the lower half of the tube very slender, the upper part subcylindrical, about 4 cm. in diameter, the limb, flaring to about 12 cm. in diameter, bearing on its margin 5 caudate teeth 6 or 7 cm long, at length recurved; nerves of the corolla and margins of the teeth clothed with soft spreading hairs; margin of the limb between the teeth not emarginate; pistil 25 cm. long, slightly exceeding the stamens; stigma slender, 16 mm. long; stamens 23 cm. long, anthers free, 37 mm. long.

Type in the U. S National Herbarium, no. 1,022,914, collected in the vicinity of Portovelo, Ecuador, October, 1918, by J. N. Rose (no. 23,418).

16. **Datura rubella** Safford, sp. nov. FIG. 2, A.

Shrub 8 to 10 feet high, with pubescent, ovate-lanceolate, acuminate, entire or repand leaves, the upper ones about 10 cm. long by 4 cm. wide; calyx pubescent like the peduncle, spathe-like, 10 cm. long, split down one side and terminating in a long caudate-acuminate point; corolla red, 13 or 14 cm. long, not widely flaring, the expanded limb about 5 cm. wide, bearing 5 slender caudate teeth about 15 mm. long; nerves of the corolla and teeth clothed with minute spreading hairs, pistil 11 to 11 5 cm long, terminating in a thick obtuse clavate stigma, slightly exceeding the stamens; stamens 10.5 cm. long, the lower part of the filaments hairy, the anthers free, linear, 2 cm. long, pale straw color, fruit (Fig. 2, A) broadly oval or lemon-shaped, 7 cm. long, 5 cm. in diameter, with a small nipple at tip.

Type in the U. S. National Herbarium, no. 1,022,434, collected in the vicinity of Cuenca, Ecuador, September, 1918, by J. N. Rose (no. 22,828). Fruit (in formalin) and seeds in Economic Collection, Bureau of Plant Industry.

17. **Datura suaveolens** Humb. & Bonpl ; Willd. Enum. Hort. Berol. 227 1809. FIG. 2, B.

Datura gardneri Hook. Curtis's Bot. Mag *sub pl. 4252* 1846.

TYPE: A cultivated plant, erroneously stated to be of Mexican origin.

RANGE: Provinces of Minas Geraes and Sao Paulo, Brazil; now much cultivated in the tropics and in conservatories; common in the Antilles.

The native country of this species, distinguished from all others by its coherent anthers and relatively short, much inflated, 5-toothed calyx, was long doubtful, and its fruit has remained undescribed. Fruiting specimens in the U. S. National Herbarium were collected near Caldas, in the province of Minas Geraes, not far from the boundary of Sao Paulo, May 12, 1873, by Dr. Anders Frederik Regnell of that city, and presented by him to the Botanical Museum of Upsala. The 2-celled fruit (FIG. 2, B) is spindle-shaped, 12 to 12.5 cm. long, 2.5 cm. in diameter at the middle, gradually tapering toward each end. It is devoid of all vestige of calyx and is borne on a recurved peduncle 7 cm. long. The dry brown pericarp is thin and fragile, glabrous, and longitudinally veined with delicate raised nerves. The large irregular angular seeds are closely packed in the two cells.

18. **Datura affinis** Safford, sp. nov.

Brugmansia arborea Lagerh. Bot. Jahrb. Engl. **20:** 663. *pl. 11, fig. 1.* 1895. Not *D. arborea* L. 1753, or *D. arborea* Ruiz & Pavon. 1799.

TYPE LOCALITY. Vicinity of Quito, Ecuador.

This species, described by Lagerheim from specimens growing in the vicinity of Quito, Ecuador, is very closely allied to *D. aurea* (no. 21). The flowers differ from those of *D. arborea* L. in their glabrous peduncle, their 2- to 5-toothed calyx, and in the margin of the corolla limb, which is not emarginate or heart-shaped between the teeth, but entire or rounded, as in *D candida*. The fruit, like that of *D aurea*, is narrowly obovate, acuminate, and pubescent. The local name is "floripondio blanco."

Lagerheim states that this species accords well with specimens labeled *D. arborea*, from Pavon's Herbarium, seen by him in the Paris Museum. This would identify it with *D. arborea* R. & P. rather than with *D. arborea* L. All specimens of *D arborea* R. & P. (*D. candida* (Persoon) Safford) examined by the writer have the apex of the calyx not toothed, but terminating in a point, and the peduncle not glabrous but pubescent.

19. **Datura dolichocarpa** (Lagerh.) Safford.

Brugmansia dolichocarpa Lagerh Bot. Jahrb. Engl. **20:** 665 *pl. 11, fig. 6–9.* 1895

TYPE LOCALITY "Habitat in Aequatoria, prope 'Santo Domingo de los Colorados,' in regione tropica provinciae Pichincha . et prope 'Puente de Chimbos' in regione tropica provinciae Chimborazo."

RANGE. Tropical Ecuador.

This beautiful species grows in the form of small trees of elegant habit It is closely allied to *D. suaveolens* H. & B. and to *D versicolor* (Lagerh.) From the former it is distinguished by its very long terete fruit (29–31 cm. long), its free anthers, its very long corolla teeth, and the form of its seeds.

20 **Datura longifolia** (Lagerh.) Safford

Brugmansia longifolia Lagerh. Bot. Jahrb. Engl. **20:** 666 1895.

TYPE LOCALITY "Habitat in Aequatoria, ad 'Santo Domingo de los Colorados' in regione tropica provinciae Pichincha (Sodiro, in Mus. botan. Univ. Quitensis")

RANGE: Known only from the type locality.

This species, with white flowers 27–30 cm. long and 2- to 5-toothed calyx, is distinguished from all the rest by its very long and narrow leaves. Its fruit is still undescribed.

21. **Datura aurea** (Lagerh.) Safford

Brugmansia aurea Lagerh. Gartenfl. **42:** 33. 1893.

TYPE LOCALITY: "Habitat in Aequatoria, Quito in hortis passim culta."

RANGE: "In silvis regionis subtropicae probabiliter spontanea."

This handsome species bears long golden-yellow flowers, with spathe-like calyces 5-toothed at the apex. It is commonly called "floripondio amarillo"

by the natives of Quito. A specimen in the U. S. National Herbarium (no 1,023,042) was collected in the garden of the American Legation at Quito in October, 1919, by Dr. J. N. Rose, who also obtained seeds (No. 28,553) and a photograph.

Lagerheim says that it may be identical with *Datura chlorantha* Hook.[11] but this is impossible. Hooker's plant does not belong to the section *Brugmansia*. It is a form of the Old World *Datura metel fastuosa*, the double flowers of which are borne on a short, thick, erect peduncle, although inverted in the illustration, and the calyx is 5-toothed like that of *Datura metel* L. Typical specimens of *D. chlorantha* were seen by the writer during a recent visit to the Island of Hawaii, growing by the roadside on the west coast of the Island. The flowers were of a greenish yellow color, identical in form with that figured by Hooker, and the fruit a prickly indehiscent capsule subtended by the enlarged persistent base of the calyx. The habit of the plant was low and spreading, as in the description of the Australian plant quoted by Hooker, not at all tree-like as in the section *Brugmansia*

22. **Datura pittieri** Safford, *sp nov.* FIG. 2, C.

Shrub or small tree with ovate-lanceolate acuminate entire leaves unequal at the base, sparsely hairy when young, at length glabrous or nearly so, 17 to 18 cm. long, 7 5 cm. broad, on glabrous petioles 2.5 cm. long, calyx spathe-like, more than half the length of the corolla (10 cm. long), glabrous, terminating at the apex in 2 obtuse teeth, corolla 18 cm. long, the tube narrow below, subcylindric and 2.5 cm broad above the middle, the limb flaring and trumpet-like, 6 cm. in diameter, bearing 5 very long caudate teeth, about 4 cm long, not revolute but curving inward, pistil 14 cm. long, the style slender and thread-like, the stigma short and thick, about 7 mm. long, stamens 13 5 cm long, the anthers free, linear, 26 mm. long, fruit (Fig. 2, C) elongate ovoid, 13 cm long, 5.5 cm. thick, devoid of terminal nipple or beak, terete, 2-celled, the cells closely packed with irregularly angled oblong seeds, pericarp thick, glabrous

Type in the U. S. National Herbarium, no. 531,502, collected in the vicinity of Huila, an Indian village in the Rio Paez Valley, Tierra Adentro, Colombia, at an altitude of 1600 to 1900 meters, January, 1906, by Henri Pittier (no 1305). Fresh fruit photographed by Professor Pittier, negative no 8708, in the files of the Bureau of Plant industry.

23. **Datura sanguinea** Ruiz & Pavon, Fl. Peruv **2:** 15 1799.

Brugmansia bicolor Pers. Syn. Pl. **1:** 216. 1805.

TYPE LOCALITY "Habitat in altis, frigidis et ruderatis locis provinciarum Tarmae, Xauxae, Huarocheri, Cantae, et Huamalies."

RANGE. Andes of Peru and Ecuador; now much cultivated in tropical and subtropical countries.

This red-flowered tree datura was collected in 1915 by Mr. O. F Cook in the Andes of Peru, attaining its perfection at an altitude of 12,000 feet, where there is frost every night. In his field notes Mr. Cook describes *Datura sanguinea* as a woody species, forming a tree somewhat smaller than *D*

[11] Curtis's Bot. Mag. **85:** *pl.* 5128. 1859.

arborea, from which it differs not only in the color and form of its flowers, but also in its more open habit and its narrower foliage; leaves narrowly oblong, tapering at each end, 18 cm. long and 5 cm. broad, the upper ones entire or slightly repand, puberulent, the petiole 8 cm. long; peduncle 3 to 4 cm. long, puberulent; calyx 9 cm. long, less than half the length of the corolla, inflated, terminating in two obtuse teeth, corolla glabrous, about 25 cm. long, the tube green from the base to beyond the end of the calyx, then light yellow, followed by red on the upper part including the limb and the teeth, the red portion having prominent longitudinal yellow nerves, diameter of the limb (including the teeth) 11 cm.; style 18–20 cm. long (shorter than the corolla tube), terminating in a thick knob-like stigma, slightly exceeding the stamens; anthers distinct, hairy, broadly linear, 25 mm. long, fruit broadly ovate or turbinate, 9 cm. long, 6 cm. thick at its greatest diameter, terminating in an obtuse nipple, the greater part enveloped in the split persistent husk-like calyx. Specimens in the National Herbarium (no. 1,022,006) collected at Ambato, Ecuador, in 1918, by J. N. Rose (no. 22,344) agree in all respects with those collected in Peru by Mr. Cook. Photographs of the flowers and fresh fruit, natural size, made by Mr Cook in the field, will appear in the writer's forthcoming paper to be published in the Smithsonian Annual Report

24. **Datura rosei** Safford, sp. nov. FIG. 2, D

Brugmansia bicolor Lindl. Bot. Reg. **20**: *pl. 1739*. 1834. Not *B. bicolor* Pers. 1805.

Brugmansia sanguinea D. Don in Sweet, Brit. Fl Gard. II. 3: *pl. 272*. 1835; Lagerh. Bot. Jahrb. Engl. **20**: 662. 1895. Not *Datura sanguinea* R. &. P. 1799.

Shrub or small tree with short leafy branches, the younger growth densely clothed with whitish spreading hairs, leaves ovate-oblong, obtuse, repand and sinuate, with short obtuse lobes, copiously clothed on both sides by soft whitish hairs, 5 to [illegible]3 cm. long, 2.5 to 12.5 cm. broad, the base rounded and often unequal, the upper ones angular-toothed and densely tomentose; petioles 2.5 to 7.5 cm. long, stout, densely subtomentose-pilose, flowers solitary, pendulous; peduncles about 2 5 cm. long, densely subtomentose-pilose; calyx densely pubescent, ventricose, less than half the length of the corolla, 7.5 to 9 cm. long, terminating at the apex in 2 to 5 obtuse teeth; corolla funnel-shaped, 15.5 to 18.5 cm. long, pubescent, orange or saffron-colored, with 15 prominent longitudinal green nerves; limb 6 to 6.5 cm. broad, divided into 5 obtuse spreading lobes each terminating in a recurved tooth 10 to 15 mm. long, the margin of limb emarginate or notched between the lobes; pistil slightly exceeding the corolla tube, 16.5 to 19.5 cm. long, terminating in a thickened obtuse stigma, stamens 5, equaling the corolla tube or very slightly exserted, the anthers closely associated round the style, hairy, 1.25 to 1.5 cm. long, fruit (FIG. 2, D) ovoid, pubescent, about 7 cm. long, 4.5 cm. in diameter, abruptly pointed at the apex, the base covered with the husk-like remains of the calyx.

Type in the U S National Herbarium, no. 1,022,538, collected in the vicinity of Cumbe, south of Cuenca, Ecuador, September 24, 1918, by J. N. Rose (no. 22,965).

RANGE: Mountains of Ecuador.

This species has been confused with *D. sanguinea*, from which it differs in

the form and indument of its leaves, the size and color of its flowers, and the size and form of its fruit. Dr. Rose, who collected both species, refers to this species in his field notes, as follows: "Brugmansia sp.—Flowers of a saffron yellow; corolla lobes acuminate, reflexed; calyx 3-lobed, green: flowers smaller, throat relatively broader, and calyx lobes more attenuate than in the red-flowered species collected at Ambato; the leaves are also relatively broader, and are distinctly lobed, or angular-toothed, and tomentose.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

ASTRONOMY.—*Results of observations with the nine-inch transit circle, 1903–1911.* W. S. EICHELBERGER and H. R MORGAN. Publ U. S. Naval Observatory, II. 9[1]. Pp. 920. 1921.

This publication contains the results and discussions of 49,437 observations of the sun, moon, planets and 4,526 standard stars made with the 9-inch transit circle of the U. S. Naval Observatory.

The following new equipment was used in the work a self-winding clock kept at almost constant temperature and pressure, the hourly rate of which is known within 0.001 sec.; a personal equation machine for determining the personal equations of observers in observing stars at all declinations and in observing the sun, moon, and planets, a high-power microscope for determining the forms of the pivots; and a screen system for partially eliminating the magnitude equation of the observer Extensive determinations were made of the forms of the new pivots, of the errors of each of the 10,800 divisions of the recently graduated circle; of the flexure of the instrument, of the errors of the new micrometer screws, and of the positions of the two meridian marks The personal equations of the observers, both in right ascension and declination, were derived from extensive inter-comparisons of the observations in connection with the results from the personal equation machine.

From the discussion of 4,000 circumpolar observations it was found that the refractions given by the Pulkowa Tables require a correction of $-0''.134 \tan z$ to satisfy the observations under the conditions under which they were taken at Washington. A comparison of the observations of 2,800 zodiacal stars made at Cape of Good Hope and at Washington confirmed this result. The variation of the refraction for different hours of the night and different times of the year was found negligible. The latitute of the Observatory deduced from this discussion is $+38° 55' 14''.34$.

From 7,000 observations, made on 410 nights, new and accurate positions were determined for the clock stars, and these positions were used in forming the clock corrections for the reduction of the work. The positions of the pole stars used in the azimuth reduction were determined, also independently of any other positions, from observations above and below pole. The discussion of the observations of the sun and moon gave a correction of -0.03 sec. to the equinox, and $-0''.4$ to the obliquity of the ecliptic, as

given by Newcomb. A comparison of the positions of the equatorial stars in this volume with those of the general catalogs of Newcomb and Boss gave the following corrections to the position of these catalogs·
In right ascension,

$\Delta\alpha$(Newcomb) = $-0^s.029$ $-0^s.005$ sin α + $0^s.005$ cos α + $0^s.000$ sin 2α + $0^s.005$ cos 2α $-0^s.0004$ (mg. -4.5)

$\Delta\alpha$ (Boss) = $-0^s.020$ $-0^s.005$ sin α + $0^s.009$ cos α $-0^s.002$ sin 2α + 0^s 004 cos 2α + 0^s 0007 (mg. -4.5)

and in declination,

$$\Delta\delta \text{ (Newcomb)} = +0''.5 \qquad \Delta\delta \text{ (Boss)} = +0.''8$$

Besides giving data for correcting the tables of motions of the sun, moon, and planets, the volume gives precise recent positions of all the stars observable in the latitude contained in the national almanacs and ephemerides and in the fundamental catalogs, and of over 3,000 stars along the zodiac used for observations of objects in the solar system. H. R. M.

ENTOMOLOGY.—*Generic classification of the hemipterous family Aphididae.* A. C. BAKER. U. S. Dept. Agric. Bull. 826. Pp. 89, pls. 16. 1920.

This paper presents a generic classification of the aphids, or plant lice. The classification is preceded by a short description of the superfamily, some remarks on its biology and phylogeny, and some statements on nomenclature. The author follows the International Code on problems of nomenclature and has been forced to make a few changes for well known genera. The type of each genus is designated and notes on the synonymy are added. The paper is illustrated by plates prepared from drawings made by the author.

S. A. ROHWER

ENTOMOLOGY —*Larvae of North American beetles of the family Cleridae*· ADAM G BÖVING and A. B. CHAMPLAIN. Proc. U. S. Nat. Mus. 57: 575-649, pls 42-53. 1920

This paper consists of two parts. The first, by the senior author, gives detailed descriptions of the known North American larvae belonging to the family *Cleridae*. This part includes a short synopsis and a detailed account of the morphology of the larval stage of these valuable predators of wood and bark-boring beetles. The author has carefully stated the material on which the descriptions are based and has explained many of the characters used.

The relationship of the various forms are discussed and it is to be noted that there is some difference in the classification proposed for the larvae, and the present classification used for the adults. This part is illustrated by 133 line-drawings made by the author.

The second part, by the junior author, deals with the habits of the adults and larvae of the known North American representatives of the groups. The available information on the life and seasonal history of the various forms is also included as well as a list of the species upon which they prey.

S. A. ROHWER.

ENTOMOLOGY.—*Memoirs on the Coleoptera, IX.* THOS. L. CASEY. (New Era Printing Company, Lancaster, Pa.) Pp. 529. 1920.

In this volume of his memoirs on Coleoptera, Colonel Casey gives a revisional study of the American *Platyninae*, a random study of the American

Caraboidea, and descriptions of the American *Barinae*. Many new genera and species are characterized. The species are treated systematically, being placed in subgenera or unnamed species groups and tabulated. In the revision of *Platyninae*, all of the species belonging to the subfamily are described in tabulated form, and in the part dealing with the *Barinae* all the species are described whether they were known to the author or not. The types of all of the new species are in the author's collection. Comments on the new species, showing their affinities to described forms, are included and make the paper more available to students. S. A. ROHWER.

ENTOMOLOGY.—*Holarctic tribes of the ichneumon-flies of the subfamily Ichneumoninae (Pimplinae)*. R. A. CUSHMAN and S. A. ROHWER. Proc. U. S. Nat Mus **57**: 379-396. 1920.

This paper contains a historical sketch of the various classifications and treatments of the Ichneumon flies belonging to the subfamily *Ichneumoninae* (formerly called *Pimplinae*), followed by a synopsis of the tribes The key is divided into two parts, the first based entirely on characters taken from the females and illustrated by insert cuts. The primary characters used in this key are secondary sexual, and much value is placed on the shape of the ovipositor. It is believed that these characters show the natural relation of the various groups The second key includes characters common to both sexes. After the synopsis, the various tribes are briefly defined and the North American genera included in them are listed. This subfamily has previously been divided into five tribes, but in the present paper the authors propose eight new ones, making the total number of tribes thirteen. S. A R

ENTOMOLOGY.—*The North American ichneumon-flies of the tribes Labenini, Rhyssini, Xoridini, Odontomerini, and Phytodietini*. S A. ROHWER Proc. U. S. Nat. Mus. **57**: 405 474 1920

In this paper the North American parasitic Ichneumon flies belonging to the groups listed in the title are described and tabulated, and some of the more typical members of each group illustrated. A few new species are described, but the paper, as a whole, is a revision and endeavors to bring together the taxonomic and biologic information available on these groups of parasites S. A R.

ENTOMOLOGY.—*The North American ichneumon flies of the tribe Acoenitini*. R. A. CUSHMAN and S A. ROHWER. Proc. U. S. Nat Mus. **57**: 503-523. 1920.

This paper deals with the parasites belonging to the tribe *Acoenitini* of the subfamily *Ichneumoninae* (*Pimplinae*) and is one of a series of papers by the authors, who have undertaken to revise the North American parasites of this subfamily. All of the genera known to occur in the Holarctic region are tabulated and the species that occur in North America treated in detail Only two of the genera of this tribe occur in the Nearctic region. One, *Coleocentrus* Gravenhorst, is treated by the senior author, and the other, *Arotes* Gravenhorst, by the junior author Full page illustrations for two well known species are included. S. A. R.

ENTOMOLOGY.—*On some Lepidoptera, with descriptions of new species, larvae and pupae.* CARL HEINRICH. Proc. U. S Nat. Mus. **57**: 53–96, pls. 1–13. 1920.

This paper deals with new species occurring in the collection of the National Museum, which have been reared by members of the Branch of Forest Insects of the Bureau of Entomology. Some thirty-odd forms are treated; one new genus, sixteen new species and two new varieties are described. Two previously described species are reduced to the rank of varieties, and full larval descriptions are given of eight species, six of which represent genera heretofore unknown in the larval stage. Descriptions of five pupae are also included.
S A. ROHWER.

ENTOMOLOGY.—*Control of aphids injurious to orchard fruits, currant, gooseberry and grape* A. L. QUAINTANCE and A C BAKER. U. S Dept. Agric. Farmers' Bull. **1128**: 3–48. 1920.

This paper, while intending primarily to aid fruit growers in the identification and control of injurious aphids, contains considerable valuable information for the student in biology. The life histories of the more important species are graphically illustrated by colored plates, which show the alternate hosts, methods of migration and various phases of the species. The paper is well illustrated by photographs and line drawings. S. A ROHWER.

ENTOMOLOGY.—*New species of Lepidoptera in the United States National Museum* WILLIAM SCHAUS. Proc. U. S Nat. Mus. **57**: 107–152. 1920

This paper contains descriptions of new butterflies and moths from Guatemala and Mexico, in the collection of the National Museum. The species described from Guatemala were collected by the author and Mr. F. T. Barnes, and those from Mexico were donated to the National Collection by Mr. Clark.
S. A. ROHWER.

ENTOMOLOGY —*Descriptions of twenty-five new species of North American Hymenoptera.* S. A. ROHWER. Proc. U. S. Nat. Mus. **57**: 209–231 1920

In this article new sawflies and parasites, most of which have been reared by members of the Branch of Forest Insects, are described, and a key to the North American species of *Exenterus* is included. S. A. ROHWER

ENTOMOLOGY —*Three new species of Indian Dryinid parasites of rice leaf-hoppers* S. A. ROHWER. Proc. U. S. Nat. Mus. **57**: 159–161, pl. 22 1920.

In this paper three new Dryinid parasites reared from the rice leaf-hoppers *Nephotettix bipunctatus* Fabricius, *Sogata pussana* Distant and *Sogata pallescens* Distant, are described and figured S. A. ROHWER.

GEOLOGY.—*Geology of the Yellow Pine cinnabar mining District, Idaho* E. S. LARSEN and D. C. LIVINGSTON. U. S. Geol. Survey Bull. **715-E.** Pp 11 (73–83), figs. 2. 1920.

The deposits are in a body of sedimentary rocks made up of quartzite, limestone, and subordinate schist only a few square miles in extent and surrounded by a great body of granodiorite. Tertiary andesite lavas overlie

the sediments and granodiorite only a mile or so from the cinnabar prospects, and numerous dikes and less regular bodies of rhyolite porphyry intrude the sediments and the granodiorite. The cinnabar deposits are in the limestones or in the sediments immediately adjoining the limestones, and for the most part they are very near the contact between the limestones and quartzites. The ore bodies appear to be irregular lenses or chimneys of silicification in the limestone, and the ore is in part the chaledonic silica and in part the friable marble that adjoins the silica bodies. Cinnabar appears to be the chief sulfide in the ore, but some pyrite is present and more may be found at greater depth. Stibnite is present in the district and is associated with some cinnabar, but it was not observed in the cinnabar ores.

The district has not been sufficiently prospected to justify any definite prediction as to the future outlook. E. S. L.

GEOLOGY.—*Coal in eastern Idaho.* GEORGE R. MANSFIELD. U. S. Geol. Survey Bull. 716-F. (Contribs. Econ. Geol., 1920, Part II.) Pp. 31 (123–153), pls. 2, figs. 3. 1920.

Many of the so-called coal prospects are in phosphate rock that superficially resembles coal and contains so much carbonaceous matter that upon distillation it yields small amounts of oil. Other supposed coal is obsidian. The carbonaceous shales of the Wayan and Bear River formations of Lower Cretaceous (?) and basal Upper Cretaceous age, respectively, though prospected, have no commercial value. The only producing mines are in Horseshoe Creek on the west side of the Teton basin. Here the coal beds, tentatively correlated with the coal-bearing Frontier formation (Upper Cretaceous) of western Wyoming, lie near and east of a great thrust fault and may be closely folded in a northward pitching syncline. The coal is bituminous and of good quality. Large scale production is probably impracticable but improvements now in progress will probably make possible a greater annual yield than formerly. A 32-inch coal bed of probably similar age and quality occurs on the Continental Divide in Clark County. There is little chance of finding other valuable coal-bearing areas in this region. A structure perhaps favorable for the accumulation of oil is noted but its exploitation would be hazardous. G. R M.

GEOLOGY.—*Natural gas resources available to Dallas and other cities of central north Texas.* E. W. SHAW and P. L. PORTS. U. S. Geol. Survey Bull. 716-D. Pp. 35 (55–89), pls. 2, figs. 10. 1920.

The bulletin presents the results of an investigation made on account of shortage of gas in Dallas in the winter 1919–1920. Natural gas resources within a circle of 300 mile radius around Dallas are deduced quantitatively for the more developed fields from figures for the pore space and volume of the gas-bearing sands and the pressure of the gas in them, with allowance made for losses in extraction and delivery. Rough estimates based on general experience and geologic conditions are made for other more or less developed parts of the area. Especial attention is given to the Petrolia field; earlier estimates by Shaw for this field are compared with present conditions and new estimates are made. Water encroachment in this field is given particular consideration, and it is concluded that it is not taking place at random but by creeping up the south flank of the dome. But as the rate of depletion of gas far exceeds the rate of water encroachment, the future losses from the latter cause will probably be slight. The bulletin contains a map showing

developments and the axes of some of the larger folds in the area considered, a structure and well map of the Petrolia field, and several curves illustrating production, decline, etc. M. I. GOLDMAN.

GEOLOGY.—*Preliminary report on the deposits of manganese ore in the Batesville district, Arkansas.* HUGH D. MISER. U. S. Geol. Survey Bull. 715-G. Pp. 32, pls. 3, figs. 4. 1920.

The report contains a brief description of the rock formations and their structure and discusses the principal geologic and economic features of the manganese-ore deposits. Detailed descriptions of the numerous mines and prospects are not given but are reserved for the final report.

The manganese ores consist of oxides, and occur as irregular masses in the nearly horizontal Fernvale limestone and Cason shale of Ordovician age, and in residual clays. The oxides have been derived from manganese-bearing carbonates and have been deposited by cold waters of meteoric origin in limestone, shale, chert, sandstone, and clay which they have replaced. Most of the masses of ore in the clays, however, are residual, having been freed from the above-named formations by their decomposition. H D. M.

PALEONTOLOGY.—*The American species of Orthophragmina and Lepidocyclina.* JOSEPH A. CUSHMAN. U.S. Geol. Survey Prof. Paper 125-D. Pp. 39–108, pls. 19, fig 1. 1920.

Orbitoid Foraminifera, on account of their short stratigraphic range, have proved to be excellent horizon markers, and because of their wide geographic distribution, they are valuable in correlation. The genus *Orbitoides*, as now restricted, is found exclusively in deposits of Cretaceous age; *Orthophragmina* appears to be confined to the Eocene; but *Lepidocyclina* ranges through the upper Eocene and Oligocene. In the present paper are described all the known American species of *Orthophragmina* and *Lepidocyclina*. This paper should be looked upon as only a pioneer attempt at making a basis on which a larger study of the American species can be built. R. W. STONE.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

333RD MEETING

The 333rd meeting was held October 7, 1920, at the Cosmos Club, with President WALTON in the chair and 25 members and 3 visitors present.

The Treasurer, S. A. ROHWER, reported a subscription of $80.00 for the purchase of food parcels to be sent to the two Austrian Entomologists who had offered rare cavern Coleoptera in exchange for such parcels. The food parcels had reached their destination, and a letter of thanks had been received from one of the entomologists.

Mr. L. H. WELD of the Bureau of Entomology was elected to membership in the Society.

The Corresponding Secretary, Mr. ROHWER, reported that he had received from the house committee of the Cosmos Club a notice of increase in the rent of the hall. He had investigated other possible meeting places and reported the most advantageous from the standpoint of both location and expense to

be Room 42–43 in the New Building of the National Museum. The matter of the place of meeting was left to the discretion of the Executive Committee.

Notes and exhibition of specimens

Dr. L. O. HOWARD described briefly the meetings of the Entomological Society of London and the Entomological Society of France which he attended during his recent visit to Europe, describing especially the methods of procedure in which these famous societies differ from our own Society. He also told of taking with him to France certain colonies of *Schizoneura lanigera* parasitized by *Aphelinus mali*. In spite of certain abrupt changes of temperature necessitated by three distinct stops in the journey, some of the parasites arrived in France in living condition and have bred in numbers, so that there is a strong possibility of the establishment of this useful species on the other side.

Dr. A. C. BAKER exhibited photographs of crystallized honey dew secreted by a species of *Lachnus* in such large quantities that it could be taken up by the spoonful.

Mr. A. N. CAUDELL reported that he had demonstrated to two of the other members of the Society the stridulation of the several legs of the house centipede. He also gave an account of his recent trip through some of the northwestern States and reported great success in the poisoning of grasshoppers.

Col. T. L. CASEY reported the finding of *Calosoma sycophanta* at Wood's Hole, Mass. Dr. HOWARD stated that it is also known to be in New Jersey

Mr. J. L. WEBB spoke of the *Thurberia* pink boll worm, reading portions of the reports of Messrs SCHWARZ and BARBER and of Dr. TOWNSEND. Mr. GAHAN mentioned a parasite of this species, a new species of *Apanteles* described by Muesebeck, the description of which is now in press

Dr. F. C. CRAIGHEAD reported the finding of a parasitic beetle in a Cicada pupa. It was determined as *Sandalus niger* of the family Rhipiceridae. Other parasitic coleopetra are found in the families Carabidae, Staphylinidae, Meloidae, Rhipiphoridae, and Colydiidae.

Mr. S. A. ROHWER spoke of the nesting habits of *Vespa*, those with the long malar space being tree-nesting, while the others nest on the ground or under stones or logs. Mr. GEORGE GREENE has reported a fallen nest still inhabited

Mr. A. N. CAUDELL told of having been stung on the inside of the lip by a yellow jacket and of effecting a cure by going in swimming.

Mr. A. B. GAHAN reported that 10 species of parasitic hymenoptera have been reared from the European corn borer, *Pyrausta nubilalis*. Only one of these has also been reared from the native *Pyrausta ainsliei* Mr. WALTON stated that so far as distribution is concerned there is no reason why the same parasites should not attack both species, for *ainsliei* is found wherever *nubilalis* is. Mr. CUSHMAN discussed certain of the parasites of *ainsliei*, stating that their habits are such that they will undoubtedly be found to attack *nubilalis*.

Mr. J. C. BRIDWELL, invited by the President to address the Society, spoke of the damage of Bruchidae to the Algaroba feed industry in the Hawaiian Islands. The industry on Oahu alone has a value of $500,000. He also spoke of some new host records on local species of Bruchids and of the generic characters in the group. He also told of the Hawaiian Entomological Society, of which he is an active member.

R. A. CUSHMAN, *Recording Secretary*.

SCIENTIFIC NOTES AND NEWS

At a meeting of the Board of Surveys and Maps held on February 8, the following officers were reelected: *Chairman*, O. C. MERRILL of the Federal Power Commission; *Vice-Chairman*, WILLIAM BOWIE of the Coast and Geodetic Survey; *Secretary*, C. H. BIRDSEYE of the U. S. Geological Survey.

The Washington Chapter of the American Society for Steel Treating met at the Bureau of Standards at 8 p.m. on March 18. Dr. G. K. BURGESS of the Bureau spoke on *The properties of metals at high temperatures and their relation to heat treatment.*

A "Personnel Research Federation" was organized on March 15 by a general conference which was held under the auspices of the National Research Council and the Engineering Foundation. The Federation has been organized to bring about the interchange of research information among the numerous organizations which are engaged in personnel research. In its membership it includes scientific, engineering, labor, management, and educational bodies. Temporary officers were elected as follows *Chairman*, ROBERT M. YERKES, representing National Research Council, *Vice-Chairman*, SAMUEL GOMPERS, American Federation of Labor; *Treasurer*, ROBERT W. BRUERE, Bureau of Industrial Research, *Secretary*, ALFRED D. FLINN, Engineering Foundation, *Acting Director*, BEARDSLEY RUML, assistant to the president of the Carnegie Corporation of New York.

The Petrologists' Club met on March 14 and discussed the following papers: F. C. SCHRADER: *Exomorphism at a contact with calcareous rocks;* F. C. CALKINS *Endomorphism at a contact with calcareous rocks,* SIDNEY PAIGE: *The Baltimore gneiss;* E. G. ZIES: *Fumaroles of the Katmai region.*

Mr. R. S. BOTSFORD of Petrograd addressed the Washington Section of the American Institute of Mining and Metallurgical Engineers on March 15 on *Mining in Russia and Siberia after the War.*

A section of the Chinese Educational Commission to Europe visited some of the scientific institutions of Washington in March. The members of the party were YUM HE LO, KEA FUNG TSUNG, F. C. WU, N. T. TSIANG, and C S TSIANG.

Dr CARL L. ALSBERG has resigned as Chief of the Bureau of Chemistry, U. S Department of Agriculture, to accept the directorship of the newly established Food Research Institute at Leland Stanford, Jr., University. The Carnegie Corporation of New York has appropriated $700,000 to maintain the Institute for ten years. The purpose of the Institute is an intensive study of the problems of the handling and distribution of food products

Col E. LESTER JONES, director of the U. S. Coast and Geodetic Survey, was appointed commissioner on behalf of the United States in the International (Canadian) Boundary Commissions just before the close of the last Congress, as successor to E. C. BARNARD, deceased. The work of the U. S. section of the Boundary Commission has been placed under the administration of the Coast and Geodetic Survey and its offices have been removed from 710 Fifteenth Street to the Survey.

At the last meeting of the American Anthropological Association Dr. JOHN R. SWANTON, ethnologist of the Bureau of American Ethnology, was elected editor of the *American Anthropologist.*

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PHYSICAL CHEMISTRY.—*Methods of stating acidity*[1] EDGAR T. WHERRY and ELLIOT Q. ADAMS, Bureau of Chemistry.

Both concentration and potential methods are in general use for stating effective acidity and alkalinity. In the former the quantity (more precisely, the concentration in gram-mols. per liter) of hydrogen ion, in the latter the logarithm of the reciprocal of this quantity, are given. The concentration method is easier to understand, as is brought out by table 1.

TABLE 1

COMPARISON OF METHODS OF STATING ACIDITY

Starting at normality:	Solution 1	Solution 2
Concentration methods		
Actual number . . .	0.0004	0.000 0002
Power of 10 with coefficient .	0.4×10^{-3}	0.2×10^{-6}
Power of 10	$10^{-3.4}$	$10^{-6.7}$
Potential method		
P_H exponent of preceding	3.4	6.7
Starting at neutrality		
Potential method		
X_H $7 - P_H$.	3.6	0.3
Concentration methods		
Power of 10 .	$10^{3.6}$	$10^{0.3}$
Actual number (specific acidity)	4000	2

In this table is shown the way two values selected at random appear under various methods; the first solution contains 2000 times as much acid as does the second. The method used in the last line obviously brings out their relative acidity with the minimum of calculation on the part of the reader, and may be recommended to writers who wish to make their data readily comprehensible

[1] Before transmitting this article for publication, it was submitted by the writers to Dr WM MANSFIELD CLARK for reply or discussion, and his comments on the subject are contained in the article following this one The discussion is closed by a brief note by WHERRY and ADAMS. Received February 2, 1921

The usefulness of methods in which computation begins at the neutral point has been urged by several writers[2] and the "X_H" and "specific acidity" methods are the result of carrying such methods to their logical conclusion. The P_H values are subtracted from 7, and the resulting values are called X_H, or chemical potentials. When X_H is negative, X_{OH}, which is equal to $-X_H$, may be used instead.

The number 7 is the exponent of the hydrogen-ion concentration of pure, neutral water, and represents the average of the values of this constant which have been obtained by some 15 different investigators, at 25°. Even though not absolutely exact, it may be conveniently taken as the standard of reference.

Correspondingly, to obtain the new concentration values, on the acid side divide the usual hydrogen-ion concentration by 10^{-7} or 0 000 000 1; and on the alkaline side divide in the reverse direction. The resulting values, since they are referred to water as a standard, may be called, respectively, specific acidities and specific alkalinities.

In a recent work,[3] W. M. Clark has raised certain objections to methods in which computation begins at the neutral point, which may well be answered here For simplicity, only the respective potential methods, X_H and P_H, will be discussed, although the arguments apply equally well to the concentration methods

(*1*) The X_H method does, while the P_H (or pH) method does not, "involve any assumption regarding the nature of that pure water which is never used, [and] which seldom is considered in calculations "

(*Ans*) The X_H method does not, while the P_H method does, involve assumptions as to the nature and the hydrogen-ion concentration of a hypothetical acid which is completely ionized in normal solution. Such an acid is at least as imaginary as is pure water, and its hydrogen-ion concentration is known with at best no greater certainty. Moreover, on the alkaline side, the P_H method *does* involve the data for pure water, for the dissociation constants of bases are expressed (however measured) in terms of OH^- concentration, and by definition pure water contains equivalent amounts of H^+ and OH^-, any discrepancy, therefore, between the H^+ and OH^- scales will be halved in the X_H method, whereas the entire error is referred to the range of alkaline solutions by the P_H method. The facts that the hydrogen-

[2] WALKER and KAY, Journ Soc Chem Ind **31**: 1013 1912, HENDERSON, Science **46**: 73 1917, WHERRY, This JOURNAL **6**. 675 1916, **8**: 591. 1918; and **9**: 305 1919, TILLMANS, Zeitschr Nahr Genussm **38**: 1. 1919

[3] *The determination of hydrogen ions*, p 28 Williams and Wilkins Co, Baltimore, 1920

ion concentration of pure water is not exactly known, and that it varies with the temperature, need introduce no difficulty, just as in our measuring of lengths it is not a vital matter that the meter is not an exact fraction of the earth's circumference.

(*2*) The X_H values are not, while the P_H values are, "directly derived from the potential of the normal hydrogen electrode."

(*Ans.*) Measurements are actually made against a half-cell, such as the calomel electrode, whose potential in the scale used, whether P_H or X_H, must be independently determined in any case. The factor by which the results of measurement must be multiplied is the same in both.

(*3*) Factory workmen can gain a correct picture of the relation of P_H values to a given process and are not bothered by the fact that the scale runs in the reverse direction from those in everyday use

(*Ans*) People of even greater intelligence than the average workman can be taught to use the Baumé hydrometer scale, the Wedgwood pottery-temperature scale, and other empirical atrocities.

(*4*) "Quantities of important data are already recorded in terms of pH " "To have two scales with numerical values so similar might produce a confusion. . "

(*Ans*) If this sort of consideration had been taken seriously in the past, we should still be using Siemens mercury units of electrical resistance instead of ohms, Dalton's instead of Berzelius's symbols for the chemical elements, and element symbols which would represent the jumble of equivalent and atomic proportions current before the time of Cannizzaro

Finally, this fact may be emphasized. Only if the validity of the laws of dilute solutions be assumed, is the potential due to hydrogen ion proportional to the logarithm of the concentration of that ion, that is, the P_H value; and yet the P_H scale takes its origin in the very region (normality) in which these laws do not hold

Is it, then, worth while to continue the use of the P_H system?

PHYSICAL CHEMISTRY.—*Reply to Wherry and Adams' article on methods of stating acidity.*[1] WM. MANSFIELD CLARK, Hygienic Laboratory.

Wherry and Adams, in their reply to my criticism of xH, have failed

[1] Received February 2, 1921 The notation used in Dr CLARK's book is followed in this article.—*The Editors.*

to deal with several of the more serious objections very briefly noted in my book. The replies they do give concede nothing to balance of judgment in weighing argument. For instance, one can sympathize with the spirit of reform in their answer under (4); but the force in an answer of this type depends upon several factors which are not apparent when the answer is isolated. Realizing that data in several distinct branches of science have been recorded in thousands of cases since 1909 in terms of pH and that there would be great practical difficulty in establishing the acceptance of Wherry's xH scale among all these sciences, one can consider the prospect of confusion to be an unimpeachable argument against the suggested change so long as no distinct fundamental advantage is shown. Then and then only will there be found any force in answer (4).

That no very distinct advantage is set forth by Wherry and Adams should be apparent from the shifting nature of their argument. Setting out originally to simplify the scale for "the worker in the non-mathematical sciences" Wherry uses the same mathematical steps in the experimental derivation of his xH that are used in the derivation of the pH scale He then introduces another scale, that of "specific acidities," and at once covers up those logarithmic relationships which it is of inestimable value to impress upon the student. In using this specific acidity scale he naively acknowledges the false step for he expresses series of soil acidities with the following series of numbers[2] for specific acidities:

300 100 30 10 3 1

The "worker in the non-mathematical sciences," after reading anew in Wherry and Adams' exposition of the xH scale that the specific acidity scale reveals their solution 1 to contain 2000 times as much acid (*sic*) as solution 2, will be puzzled to know why Wherry uses such a peculiar series of numbers for soil acidities.

The secret is that Wherry knows the intrinsic physical value of a logarithmic scale (pH or xH) and has spaced his specific acidities to correspond with 0 5 point on a logarithmic scale. In this way specific acidities are made to come to the defense of xH! Wherry, in his papers, has not enough confidence in the xH scale to use it.

But a discussion of this and similar matters would be hardly worth while unless the real source of our difference in point of view could be reached I believe I find it in the answer Wherry and Adams give

[2] Proc Acad. Nat Sci, Philadelphia, April, 1920.

under (1). There the point of view of a theorist seems to be confused with the point of view of an experimentalist. Wherry and Adams wish to divide the acidity-alkalinity scale into two distinct regions, a region of "acidity" and a region of "alkalinity," divided from one another by the theoretical neutral point Now the experimental indicator method of determining "reaction," while it need not necessarily be so, is still based experimentally upon hydrogen electrode measurements. The hydrogen electrode in turn gives us, according to present conceptions, an indication of hydrogen-ion concentration or activity and tells us nothing at all directly regarding the hydroxyl ion. Our two chief methods therefore are concerned only with hydrogen-ion concentrations or activities. In view of the fact that our experimental standards of concentration are somewhat indefinite it might be wise were we to express our data in terms of electrode potential differences, but we have chosen to employ pH values which are a linear function of those potential differences In so doing we have introduced no consideration regarding hydroxyl ions Hence the student employing pH values for any region of the scale, including that which other considerations lead us to designate as the "alkaline" region, can easily be taught the physical and experimental significance of the values.

Furthermore, since the pH scale shows no change of sign or alteration of its continuity at the "neutral point" it gives the student a correct picture of the continuity in the actual conduct of the hydrogen electrode as solutions pass this point, and a correct picture of the continuity in the acid-base system of equilibria at or on either side of a point which we take into consideration only in calculations of certain theoretical values.

Wherry and Adams are of course clear in their minds about the matter, but their remark that the pH method of statement involves the data for pure water is made in such a way that it tends to confuse experimental physical facts with theoretical considerations When we use the dissociation constant of a base (as determined for instance by conductance methods) to fix the approximate position of its equilibria on the pH scale we introduce several theoretical implications and should be conscious of the risk When we use the dissociation constant of a base, as determined by hydrogen electrode measurements and expressed in pH values, we can correctly use the data to fix the position of the equilibria on the pH scale but the constant so found involves additional theory when we compare it with the con-

stants found by other methods of measurement In the translation of values from one experimental system to another the dissociation constant of water is frequently involved But this constant Wherry introduces at the very beginning while the user of pH introduces it only in a limited number of cases and when he wishes to make theoretical calculations of the kind which the botanist (for whose benefit xH was devised) has so far not employed

Our difference in point of view, then, if it can be traced beyond matters which the future alone will balance properly, seems to rest upon this Wherry's xH scale presents to the student a symmetrical picture easily grasped when approached with our habitual conception of a vital distinction between acidity and alkalinity and when the derivation is not attempted The pH scale emphasizes the experimental derivation of values and the actual continuity in the acid-base system of equilibria

In the use of either scale there are involved difficulties in the experimental setting up of the ultimate standards and recognizing this I have taken care in my book to suggest (in Chapter XVII) that there be, tentatively at least, agreement of the same nature that fixes our scales of length and weight But I fail to see how the difficulties which are here involved are in any way lessened for the experimenter by setting up a definition of a new reference point as Wherry has done in choosing the hydrogen-ion concentation of pure water in place of normal hydrogen-ion concentration

Note by Wherry and Adams

We readily concede that the 1 3+ . 10 series has the real disadvantage of unfamiliarity, but so does the series 1 : 1 6 2 5 : 4 0 · 6 3 10 used by Clark Trisection of the interval between 1 and 10 would give a series, 1 · 2+ 5– · 10, which is already familiar, in coinage, and therefore preferable

But surely the use of specific acidities no more connotes lack of confidence in the X_H scale than the measurement of electric current in amperes implies disrespect to Volta, after whom the unit of electrical potential is named The X_H (potential) values may well be translated into the corresponding specific acidities (quantities) whenever the experience of the readers for whom a contribution is intended makes the method of statement by quantities more readily understandable

EDGAR T WHERRY and ELLIOT Q ADAMS

GEOLOGY.—*Scientific by-products of applied geology.*[1] GEORGE OTIS SMITH, U. S. Geological Survey.

"By-product" is a term that suggests large-scale industrial engineering and perhaps even "big business." By-product practice carries the complex idea of waste turned into profit, of painstaking engineering converting the raw material into many products, and of persistent salesmanship that finds a market for commodities as varied as dynamite and toilet sets or hams and violin strings. Yet, except in its larger commercial aspect, by-product practice is not limited to modern times or to large corporate enterprise; conserving the incidental or the "left-over" was also a virtue of our forefathers. The giving of value to the additional or secondary products and their successful disposal with profit to all, however, seems the modern expression of old-fashioned thrift.

So, while no doubt applied geology has always paid its tithes in the form of incidental contributions to the theoretical side of the science, it is probably true that as our geologic efforts have been spread over larger fields, with greater variety of endeavor, these scientific by-products have come to represent greater values to the world of science. As a large operator in applied geology, the United States Geological Survey would be blind to its opportunity if it failed to utilize these scientific by-products, and indeed it is to be hoped that this Federal service has caught the commercial spirit at least to the extent of seeing large profits in by-products. The other type of by-products—economic results incidental to research—would make a more impressive showing; but that is another story, well worth telling under other auspices.

In the program of geologic work of the United States Geological Survey for the last decade three phases of applied geology stand out prominently—land classification, oil and gas exploration, and the study of mineral reserves both in our own and foreign countries Each of these phases represents a task laid upon the Survey by a national need, but none of them at first glance is expected to include research into fundamental principles of the science of geology. In fact, they have all been looked upon as a levy upon the science rather than as an aid to its progress. However, it may be opportune to pause and suggest some of the valuable by-products of all this work that has absorbed so much of the activities of geologists of high scien-

[1] Presented before the Society of Economic Geologists at Chicago in December, 1920, and the Geological Society of Washington on April 13, 1921. Received April 2, 1921

tific training and attainments To list all these scientific by-products, however, would result in a bibliography imposing in both length and quality.

The principal beneficial influence of land classification surveys upon our science has operated through the requirement of quantitative detail and the necessary training for close observation. The geologist trained in this work has, through great travail of spirit, attained notable accuracy in field methods, which has reacted favorably upon standards of work throughout the field organization.

The results of scientific value incidental to the large expenditures of effort and money in the classification of public coal, phosphate, and oil lands have included the increased interest in stratigraphic problems and the increased attention to structural details, overlooked in broad regional studies, and to variation in sedimentation. It is not too much to say that a large part of the present knowledge of the Cretaceous and early Tertiary stratigraphy and paleontology of the West can be traced directly to the public coal-land work, broadly administered by Campbell. The Laramie question became a live issue, Stanton, Lloyd and Hares recognized and discussed new problems in the Lance of the northern area, just as Gilmore contributed to the paleontology of the southern area; Lee and others made substantial revisions of the stratigraphic column for the eastern flank of the Rocky Mountains, and far to the north, Hollick's monographic study of the Cretaceous flora of Alaska and Martin's work on the Mesozoic stratigraphy of Alaska, of which the Triassic chapter has been published, are a direct outgrowth of the coal and oil investigations. With these and many other highly scientific contributions in mind, it is not too much to credit the fifteen years devoted so largely to examination of the Nation's coal lands with an addition to our geologic knowledge of the West fully comparable with the pioneer results of the similar period of exploration over the same area forty years earlier The new geologic map of Wyoming now ready for publication is in largest part the result of the activities directed primarily to classifying oil and coal land.

Less obvious, perhaps, have been the scientific results of the increased attention given to structure, such as the recognition and description of the Bannock overthrust by Richards and Mansfield in mapping phosphate rocks in Idaho or the interpretation of the Hart Mountain overthrust by Hewett as a by-product of his coal and oil work in Wyoming, although the discovery of this great overthrust is

to be credited to Dake. These are displacements on a large scale, but observations of structural details have formed an essential part of the general geologic descriptions by other geologists A few petrographic contributions have also resulted, such as the discovery of the nepheline basalt on the Fort Hall Indian Reservation by Mansfield and the detailed mapping of the Leucite Hills by Schultz

The close observation necessary in tracing coal outcrops and in valuing public lands according to the thickness and character of the coal beds has naturally led to intensive study of variation in sedimentation. Thom's work on the Lance and Fort Union sediments, in which the source of sediment deposited in flood-plain swamps is traced by means of microscopic examination, and Hewett's discovery of the persistent presence of bentonite in the Upper Cretaceous series, proving volcanic activity in four States, are important contributions to paleogeographic science—despite the bar sinister.

The observed influence of the oil and gas studies by the Federal geologists has aroused a larger interest in geophysics and in physical chemistry, an influence which shows itself for the most part only indirectly but is none the less of large profit to our science Here again close attention to structural details is yielding theoretical contributions, but probably the most noteworthy by-product of the oil and gas work of the United States Geological Survey has been the augmented interest in the petrology of sedimentary rocks. For purposes of correlation and of interpretation of the details of "oil sand" stratigraphy, petrographic methods must be developed and used Questions of oil genesis, accumulation, and recovery lead to theoretical problems whose solution will deepen our insight into earth processes.

The study of mineral resources stimulated by the war also yielded scientific profits, both subjective and objective Foremost among these I would place the appreciation of the physiographic relation of manganese oxide deposits to stages of planation and of the fact that degree of rock decay depends more upon physiographic stage than upon climate; and the fact that the tracing of deposits of manganese ore in the Appalachian Valley region disclosed a planation stage that had previously received little attention

The study of the literature of foreign mineral reserves as a part of the American problem of raw material supply has also added to our appreciation of exact statement in geologic reports. The critical reader of scientific literature may even profit by the faults of others, and our geologists who have made largest use of the reports on the

ore deposits of the world have acquired the keenest understanding of what standards are needed in geologic work, in both field and office. This intensive study of the commercial side of geology should tend to make our science more exact.

In the course of a discussion at the Baltimore meeting of the Geological Society of America, Dr. Iddings hesitated to characterize pure geology as unapplied geology, and my suggestion was that pure science is simply not-yet-applied science. I believe this descriptive definition stands the test of our experience, and a long list of economic by-products of pure geology could be cited as proof. One such example of the later application of the results of a purely scientific investigation to everyday use of large value may be mentioned here because it illustrates the final point I wish to make. Alden's glacial studies in Wisconsin, which were continued over a decade and covered about 10,000 square miles, resulted in two professional papers, one bulletin, and one geologic folio, each a contribution of high scientific and educational value. Now, an extensive and intensive program of State highway construction has given to this geologic study a value not anticipated. Measured by the commercial standards of value, Alden's glacial mapping is expected to save the State of Wisconsin in the location of road material at least two and half times what the geologic work cost the Federal Survey. The economic by-product thus more than repays the production costs, and any economist can see a large profit in the operation.

The general trend in useful geology is to call for quantitative results, and indeed exactness is more truly scientific than vagueness. Moreover, the testimony of experience is that whatever the purpose of a geologic project, if its execution is thorough-going, its methods exact, and its standards high, it will yield by-products of value. It is therefore from the best of scientific research that economic by-products are obtained and it is only from applied geology well applied that scientific by-products may be expected. The incidental is not accidental.

The personal element in geologic by-product practice is not to be overlooked in this brief résumé of the subject. Geologists differ in both their telescopic and their microscopic vision, and even more in their catholicity of interest The field observer whose eyes are open to every type of geologic phenomena, is pre-eminently a by-product man, and whether his primary object is the examination of a dam site or the correlation of two interglacial formations, he returns with note

book and mind enriched with all that he saw, so that the by-products may eventually outvalue the answer to his original problem. Mr Gilbert well illustrated the geologist whose researches yielded so great a wealth of products, and in his work the line between pure geology and useful geology was not marked In that type of geology, broad in scope and accurate in detail, by-products of high value can always be expected.

ZOOLOGY —*The steps in the evolution of animals*[1] AUSTIN H CLARK, U S. National Museum

In the following dichotomous table are included all the essential characters of all the major animal groups, showing the successive steps by which the two most specialized phyla, the Vertebrata (in heavy-faced type) and the Arthropoda (in italics), have been evolved, and at the same time the relationship to the main developmental line of all the numerous off-shoots which have proved incapable of further evolution.

This table, which is based upon the body structure of adults, assumes the evolutionary course to have run as follows

1. The formation of a multicellular body overcame the limitation in size inseparable from the unicellular body.

2. The appearance of quadrilateral symmetry (with a right and left side and a dorsal and ventral surface) and the correlated development of a head end overcame the inefficiency of a radially symmetrical body.

3 The development of a vascular and of a respiratory system facilitated the repair of waste and led to a marked increase in bodily activity.

4. The development of a skeleton enabled the muscles to function to better advantage, leading to a more perfect coordination of muscular action and greater perfection of bodily activity

5. The appearance of gill clefts indicated the final stage in the centralization and perfection of the previously unorganized respiratory system.

6. The development of the dorsal nerve cords led to increased nervous efficiency through the unification and concentration of the nervous system

7. The development, in connection with the last, of a definite head, was the final step in the centralization of the nervous control of the body.

[1] Received March 9, 1921.

- Unicellular
- **Multicellular**
  - Radially or bilaterally symmetrical
    - No definite organs nor body form
    - With definite organs and body form
  - **Quadrilaterally symmetrical, with a head end**
    - No vascular, respiratory or skeletal system
      - Without a special food collecting mechanism
        - Flattened
        - Cylindrical
      - With a special ciliated food collecting apparatus
    - **With a vascular system and a respiratory system**
      - No true skeleton
        - Unsegmented
        - Segmented
      - **With a skeleton**
        - Without gill clefts
          - Skeleton soft
          - *Skeleton hard*
            - Unsegmented externally
              - With a tentacular food collecting mechanism
              - Without a special food collecting mechanism
            - *Segmented externally*
        - **With gill clefts**
          - Nerves ventral
            - With a tentacular food collecting mechanism
            - Without a special food collecting mechanism
          - **Nerves Dorsal**
            - No definite head, and a special food collecting mechanism
              - Food collecting apparatus internal
              - Food collecting apparatus tentacular and external
            - **With a definite head**

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

PHYSICS.—*The efflux of gases through small orifices.* EDGAR BUCKINGHAM and J. D. EDWARDS. Bur. Standards Sci. Paper **359.** Pp. 47, figs. 7. 1920.

This paper contains a theoretical discussion of the results of experiments made during an investigation of the effusion method of determining gas density. The effects on effusion of viscosity and thermal conductivity of the gas are studied, and formulas for representing these effects are developed and compared with the observed facts. A physical interpretation is thus obtained for the most striking of the apparent anomalies observed in the behavior of gases flowing through very small orifices such as are used in apparatus for determining density by effusion The resulting agreement of the theory with the observations is exhibited graphically It is fairly satisfactory but not perfect, and its imperfections suggest the directions in which further experiments should be made J. D. E.

PHYSICS —*The constants of radiation of a uniformly heated enclosure.* W. W. COBLENTZ Bur of Standards Sci Paper **357.** Pp 11 1920

Experimental data are given on atmospheric absorption. The paper gives also a recalculation of the coefficient of total radiation of a uniformly heated enclosure, or so-called black body, giving a value of 5.72×10^{-12}. The effect of atmospheric absorption is discussed, and the conclusion arrived at is that, if corrections are made for atmospheric absorption, the value recently obtained at Naples is close to the average value, *viz.*, 5.7. In the second part of the paper, the present status of the constant of spectral radiation is discussed. W. W. C

PHYSICS —*An integration method of deriving the alternating current resistance and inductance of conductors.* H. L. CURTIS. Bur. Standards Sci. Paper **374** Pp. 35, figs 4 1920.

The solution of the problem was met by a process of integration. The conductor is divided into infinitesimal filaments by surfaces which coincide with the lines of flow The magnetic field at any point is the sum of the magnetic fields of all these filaments. The counter-electromotive force in a filament is determined by the rate at which the magnetic fields of all the others cut this filament.

Formulas for the alternating current resistance and inductance of a straight cylindrical conductor were derived by the use both of real and imaginary power series. These formulas correspond exactly with the asymptotic formulas of Russell. The same method is applied to a return circuit making use of imaginary series, and formulas for the alternating current resistance and inductance are derived Values computed by these formulas are compared with experimental results. H. L. C.

PHYSICS.—*The variation of residual induction and coercive force with magnetizing force* R. L. SANFORD and W. L. CHENEY. Bur. Standards Sci Paper **384**. Pp. 10, figs. 6. 1920.

This paper is a report of an investigation to ascertain whether or not analytical expressions similar to the reluctivity relationship of Kennelly correctly represent the variation of residual induction and coercive force with the maximum magnetizing force Hysteresis measurements were made on a number of samples covering a wide range of material using magnetizing forces up to 2500 gausses The relationships $H_m/B_r = a_1 + b_1H_m$ and $H_m/H_c = a_2 + b_2H_m$ were found to hold within the limits of the probable experimental error W. L. C.

SPECTROSCOPY —*Relative spectral transmission of the atmosphere* E. KARRER and E. P. T. TYNDALL. Bur. Standards Sci Paper **389**. Pp. 37, figs. 20 1920

Data on the relative spectral transmission are given, (1) for a clear atmosphere, (2) for the atmosphere of high humidity, and (3) during rains. The curves for (1) show little selectivity Between wave-lengths 520 and 660 mμ the transmission is uniform At 660 it begins to decrease. Also from 520 to 440 mμ it gradually and continuously decreases The curves for the atmospheric condition of (2) and (3) are almost identical for the region from 430 to 560 mμ, the transmission increasing with the wave-length. In the region from 560 to 670 mμ the curve for the rainy atmosphere shows a maximum near 640 mμ, while that for the atmosphere of high humidity indicates two maxima, at 580 and at 650 mμ, with a miminum near 620 mμ The decrease at 660 mμ in both cases is very similar to that noted for the clear atmosphere, and is probably to be associated with the absorption band of the oxygen of the atmosphere. E. K.

SPECTROSCOPY —*Wave lengths longer than 5500Å in the arc spectra of seven elements* C. C KIESS and W. F. MEGGERS. Bur. Standards Sci. Paper **372**. Pp. 29, fig 1. 1920.

The concave grating spectrograph of the Bureau of Standards was used to photograph the yellow, red and infra-red arc spectra of titanium, vanadium, chromium, manganese, molybdenum, tungsten and uranium. This work is a continuation of a program of standard wave-length determination and spectroscopic analysis which has as one of its objects the mapping of the spectra of chemical elements as far out into the region of long wave-lengths as modern photographic methods will permit.

The spectrograms were made on photographic plates sensitized to the long waves by bathing in solutions of dyes Recently "made-in-America" dyes were used for many of the plates and were as effective in their photosensitizing action as the imported ones. The wave-lengths of more than 2500 spectral lines were derived from the measurement of the plates. These wave-lengths extend from the green at 5500 Å into the infra-red beyond 9700 Å. So far as known, impurity lines and spurious lines have been eliminated from the wave-length tables. Frequency differences which are suspected of being constant have been found in each of the spectra here presented C. C. K.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

841ST MEETING

The 841st meeting was held at the Cosmos Club, November 20, 1920, with President SOSMAN in the chair and 50 persons present The program was as follows

C F. MARVIN *The law of the geoidal slope and fallacies in dynamic meteorology.*

This paper presented matters of unusual interest and importance relating to what are believed to be important fundamental errors in mathematical meteorology which have almost completely eluded detection throughout the past sixty years Within that time the faults in question have been subscribed to by many of the highest authorities on the dynamics of atmospheric motions among both popular and mathematical writers.

The question deals with a correct representation of the possible motion of the atmosphere or of any bodies on a rotating globe when the motions occur entirely without friction of any kind This question has occupied the attention of scientists for nearly 200 years. A correct statement of the underlying dynamic principles was first arrived at about 1858 by one of our own countrymen, WILLIAM FERREL, a member of the Philosophical Society after 1872. FERREL was many years the senior and the leader of all other writers on the mathematical analysis of atmospheric motions, and it is difficult to adequately commend the originality and completeness of his studies. Notwithstanding this there appear to be certain errors in his application of the principles of his own discovery. These have since been perpetuated in many standard text-books on meteorology which call attention to the super-hurricane wind velocities required by the operation of the law of equal areas and claim that these inconceivable velocities are prevented by atmospheric friction, convection, turbulence, etc.

These conclusions are inconsistent with Ferrel's very lucid demonstration that the action of gravity upon bodies moving freely over a rotating globe is expressed in two wholly independent inertia reactions. One of these has long been known and dignified by a specific title, the law of the conservation of angular momentum. The other reaction has also long been known, but strangely enough has never been christened. The important part it plays in controlling the motions of the air has been overlooked, or ascribed to friction and turbulence. Believing these errors to have arisen and spread, at least partly, because of the lack of an appropriate name, it is proposed that the neglected principle be designated by the name of the *law of the geoidal slope.*

For a globe rotating from the west to the east the law may be stated to be *A geoidal surface is a neutral or horizontal surface only for bodies at rest upon it. That is, gravity is powerless to set up any lateral motions among such bodies. The surface slopes towards the equator for every body having a relative motion eastward and towards the pole for every body with a motion westward. A component of the force of gravity pulls the moving bodies down the slopes.*

Without giving a specific name to the tangential pull of gravity down the slopes, Ferrel nevertheless clearly showed that the *resultant* of this reaction and that arising from the law of equal areas was continually at right angles to the direction of motion of bodies, therefore this deflective influence of the earth's rotation is powerless to change velocities but tends continually to change direction of motions It was made clear in the paper that *it is the pull of gravity down the geoidal slopes*, not friction, which prevents the super-hurricane velocities exploited in the text-books

The paper discussed briefly the equation for the steady motions of the atmosphere under balanced forces, both with and without friction, and for different types of pressure distribution The application of these equations was shown for the case of an ideal frictionless circumpolar cyclone based on pressure charts for January conditions in the free air at an altitude of 1500 meters. The velocities for this circulation are all shown to be reasonable and moderate and are irreconcilable with the super-hurricane polar winds required by the generally accepted mathematical theories when friction is zero

The paper was illustrated with experiments and lantern slides, and has been published in full in the *Monthly Weather Review* for October, 1920

Discussion The paper was discussed by Messrs LAMBERT, BREIT, SOSMAN and KIMBALL

W R BLAIR *Weather information for operating concerns* (no abstract received)

Discussion The second paper was discussed by Messrs BROOKS (C.F), MARVIN, SMITH, WHITE, SOSMAN, FERNER, KIMBALL, FRANKENFIELD, and CALVERY

ANNUAL MEETING

The 842nd meeting and 50th annual meeting of the Society was held at the Cosmos Club December 4, 1920 President SOSMAN presided, and 25 members were present

The report of the Secretaries showed the present active membership to be 213, with a net gain of 19 for the year One active member of the Society, Mr C H SINCLAIR, died during the year Thirty-seven new members were elected and qualified, 5 were transferred to the active from the absent list, 17 were transferred to the absent list, 2 resigned, and 2 were dropped During the year the Society held 16 meetings for the presentation of papers The average attendance at these meetings was 44, and the total number of papers read was 37

The report of the Treasurer, Mr J A FLEMING, showed receipts of $1318 42. Of this amount, $639 25 was from dues, $632 67 from interest, and $46 50 from miscellaneous sources Total 1920 maintenance expenses were $958 62 $490 90 was invested in United States Liberty Bonds The securities held by the Society amount to $13,500 The report of the Auditing Committee, consisting of W R. GREGG, OSCAR S. ADAMS and H F STIMSON, was presented by Mr Gregg, and the reports of the Treasurer and Committee were accepted

The report of the Tellers, H S ROBERTS, CHARLES R. DUVALL and S. J. MAUCHLY, was presented by Mr Roberts The Society proceeded with the election of officers, which resulted as follows *President*, R. L FARIS, *Vice-Presidents*, E C CRITTENDEN and WALTER P. WHITE, *Recording Secretary*, H H KIMBALL, *Treasurer*, JOHN A FLEMING.

In view of his election as Vice-President, Mr. W. P. WHITE tendered his resignation as Member-at-large of the General Committee. His resignation was accepted, and members-at-large of the General Committee were elected as follows: F. B. SILSBEE and O. S. ADAMS for regular 2-year terms, and W. R. GREGG for one year, to fill the unexpired term of Mr. White.

In accordance with action of the Society at its last annual meeting, the General Committee submitted, in the form of a printed memorandum, its recommendations for changes in the by-laws of the Society. Three of these were adopted, and one was referred back to the General Committee for further consideration. The principal change was in the methods of nominating and electing officers S J. MAUCHLY, *Recording Secretary*

BIOLOGICAL SOCIETY

616TH MEETING

The 616th meeting was held in the lecture hall of the Cosmos Club on November 27, 1920 Prof. A. S. HITCHCOCK called the meeting to order with 46 persons present. The following were elected to membership R. A. CUSHMAN, H. E. EWING, R. M. FOUTS, T. C. GREENE, CARL HEINRICH, W. M. MANN, H. MORRISON, W. SCHAUS, L H. WELD, C. E. THOMPSON, T. B. WILSON, C. R ASCHMEIER, A. L BENNETT, N. H BOSS, W. L. BROWN, T. HORN, J. B. REESIDE, JR., MISS G. O VISEL, P. C VILLANNERA, D. H. ADAMS, MISS L. ALLISON, G. L BOWEN, T. J BRINEER, C. T. BUCKINGHAM, MISS A. M. CHAREST, MISS E E. CHICKERING, W F COAKLEY, G. W. CRESWELL, F B. CUNNINGHAM, W G CUSNARD, W DEAN, J. DEUTERMAN, MISS A E. DREW, MISS M E DREW, E S DRUMMOND, D. L DUPRE, E. M ELLERSON, P. S. GAULT, W. H. GEISLER, W A. GERSDORF, E J GRASS, MISS H. F. HADDEN, MISS E M HAMRIC, MISS DORA HANSEN, S. M. HARDING, G. S. HASTINGS, W. H HUGHES, W. JOHNSON, J. L. MCCARTHER, F. A. MAYER, MISS A J. MILLS, F MOORE, R W. MURRAY, MISS E. NATHANSON, A. D. O'DONNELL, MISS H R OSTROM, L A. PASSALAEQUA, C W. PARKER, H. W. POTTER, A PREECE, R. B RENCH, M. RIWCHUN, G. L. ROBERTS, A. S. RUBINO, MISS M. RUSSELL, G. P. SAVAGE, H. L. SMITH, MISS L. W. STEEVER, H C STRAUP, MISS LURANA VAN DOREN, L. R. WATSON, JR, S WEINSHELLBAUM, MISS D. V NICHOLS

Informal communications

Dr L O HOWARD referred to HUMBOLDT's statement that mosquitoes occurred in enormous numbers on the Amazon, and Dr. BRADLEY's statement that they occurred only in spots, and asked Dr. Bradley for comments. Dr. J C BRADLEY in reply said that his experiences might have been in an off season, he was, nevertheless, struck by the comparative absence of mosquitoes. On the Amazon no *Anopheles*, and no malaria; on certain tributaries some *Anopheles*, and some malaria, elsewhere only scattering mosquitoes, and no malaria, at other places no mosquitoes, yet malaria is reported. In general the distribution of mosquitoes seems to be quite local.

Dr H M. SMITH exhibited specimens of "unnatural history" from Peking, China—artificial lizards, scorpions, millipeds, etc, made from beads, seeds, and common materials. Dr. T. S. PALMER called attention to the special exhibit of bird drawings at the Library of Congress, some very ancient, some recent and the best of their kind. Dr. L. O. HOWARD also announced the special exhibition of insect drawings at the Corcoran Art Gallery.

Regular program

J. CHESTER BRADLEY: *Plumarius, an aberrant genus of Hymenoptera.* In 1873 Philippi described a male hymenopterous insect under the name *Plumarius*, referred tentatively to the family Evaniidae. From that time to the present the identity and relations of this insect have been a puzzle to zoologists. In 1909 André described the genus *Konowiella*, also from the male sex only, remarking that he was unable to assign it to any family. Specimens from Argentina in the hands of Professor BRUES and the writer, evidently of *Konowiella*, brought out the probability that it is synonymous with *Plumarius*, that it is an arid region form, and nocturnal.

Entomologists in Argentina were not able to throw any light upon the time of year, habits, occurrence or identity of these insects, but in the arid foothills of the Eastern Andes near Mendoza the speaker obtained last March about 100 specimens, attracted to light, of five or six species, and later two specimens on the western side of the Andes in Peru. It is thus evident that the insects represent a numerous and not uncommon group in the Andean arid regions, and perhaps may be analogous in their economy to *Brachycistis* of our Southwestern deserts.

Subsequently, at Santiago, the speaker found in the National Museum Philippi's type of *Plumarius*, and has been able to prove the identity of *Konowiella* with that insect.

Ashmead and Szepligeti had placed *Plumarius* in different subfamilies of Braconidae, and the speaker, eleven years ago, had inclined to the belief that it represented a distinct ichneumonoid family. André believed his *Konowiella* allied with the Mutillidae, Thynnidae and Scoliidae.

With the Evaniidae and Braconidae *Plumarius* has no affinities. It is an aculeate, possessing 1 segmented trochanters, 13-segmented antennae (not more than 16-segmented, as stated by Philippi), and a distinct preaxillary incision in the hind wings, a character of many aculeates, but of no Ichneumonoidea. The hind wings are also in venation quite of the aculeate type.

Two accessory veins in the forewing appear at first sight without analogy in other wasps. A study of the forewing of *Scaptodactyla* and *Photopsis*, however, demonstrates the manner in which these veins have really arisen from the accessory spurs characteristic of many Mutillidae.

In many respects the insects resemble male ants, but lack petioles. The body characters are neither strongly dissimilar, not do they entirely agree with the Mutillidae and their allies. The genitalia are of a type not dissimilar to Myrmosidae. Cerci are present.

André was undoubtedly correct in suggesting the affinities of these insects with genera which we now place in the Myrmosidae. Yet the relation must not be considered too close. The only justifiable conclusion is to erect for these insects a new family which must take its place as related to Mutillidae and Myrmosidae.

It is to be regretted that we do not know the female, but it is undoubtedly apterous. (Author's abstract.)

This paper was discussed by L. O. HOWARD and S. A. ROHWER.

W. E. SAFFORD: *Hawaii revisited.*

The Hawaiian Islands have been visited several times by Dr. Safford. In the paper presented by him he dwelt upon the changes which have taken place in the natural and social conditions between his first visit thirty-three

years ago, when Kalakaua was King, and his last visit, when he was sent to the islands as delegate from the U. S. Department of Agriculture to the First Pan-Pacific Scientific Conference, held at Honolulu from August 2 to August 20, 1920.

During the Conference Dr. SAFFORD presented papers treating of the dissemination of plants by ocean currents, the introduction of plants in prehistoric times through human agency, and the role played by the vernacular names of economic plants as indices to the origin not only of the plants but of the people who introduced them. A number of lantern slides were shown illustrating the arts and customs and the physical appearance of the primitive inhabitants and showing the contrast of the Hawaiian Islands as first seen by the lecturer with the Territory of Hawaii of today, with its great sugar and pineapple industries, the rice-fields and water-lily ponds of the Chinese and Japanese, which have almost supplanted the taro-patches of the natives, and the magnificent modern city which has grown out of the early Honolulu, with its homely residences embowered in palms and ferns, and the grass-covered houses of the natives nestling in the valleys surrounded by taro-patches and clumps of 'awa plants from which their narcotic drink was prepared.

Slides were also shown illustrating the former lava flows on the Island of Hawaii, and the crater of Kilauea, whose activity still continues

Dr. Safford paid a tribute to the generous hospitality received by the members of the Conference and called attention to the admirable organization of the Hawaiian Sugar Planters' Association and to the impc tant work accomplished by the U S. Department of Agriculture Experiment Station at Honolulu, under the management of Mr J M WESTGATE

The part of this paper relating to the flora of the Islands and the role played by economic plants introduced in prehistoric times in the daily life of the primitive Hawaiians will be published elsewhere. (Author's abstract)

A. A. DOOLITTLE, *Recording Secretary*

ENTOMOLOGICAL SOCIETY

334TH MEETING

The 334th meeting of the Entomological Society of Washington was held in Room 43 of the new building of the National Museum on November 4, 1920 President WALTON presided and there were present 33 members and 9 visitors. Messrs J C BRIDWELL, of the Bureau of Entomology, and L L. BUCHANAN, of the Biological Survey, were elected to membership

Regular program

L O. HOWARD *A recent visit to certain European entomologists*

This was a running account of Dr. Howard's recent visit to Europe, illustrated by many lantern slides of the entomologists whom he met and of places of entomological interest. The personal characteristics, work, and special interests of the various entomologists were discussed

N. E. McINDOO: *The auditory sense of the honey bee.*

Beekeepers are agreed that bees can hear, yet they cannot prove it, and critics still contend that it has never been experimentally proven that any insect can hear; nevertheless, within the last few years some good experimental results have been obtained.

The special sound-producing apparatus of the honeybee consists of the membranes lying between the axillaries at the bases of the front wings.

Muscles, lying in the thorax and attached to these axillaries, contract and relax very quickly, thereby causing the axillaries to vibrate, consequently the above membranes are caused to vibrate rapidly, thus producing the piping, teeting, or squealing noise, commonly heard when a bee is squeezed.

Up to date, five so-called auditory organs have been found. Judging from their anatomy, the pore plates, Forel flasks, pit pegs and Johnson's organ, all located in the antennae, do not seem to be well fitted to act as sound receptors; but the chordotonal organs, lying in the tibiae, seem to be better adapted for this purpose. The Johnson's organ consists of the peculiarly modified articular membrane between the second and third antennal segments, and of many sense cells whose fibers unite with peculiar knobs extending inwardly from the articular membrane. The chordotonal organs are quite complicated, resembling those in certain Orthoptera.

The sound-producing apparatus and Johnson's organ in the honeybee, and also a minor detail in the histology of the pore plates, are here described for the first time.

Notes and exhibition of specimens

Mr. AUGUST BUSCK showed specimens of the Oscophorid *Carsina quercana* Fabricius which had recently been received by him for determination from Mr. E H. BLACKMORE, of Victoria, British Columbia. This is the first American record of this European genus and species and is an interesting addition to our list of Microlepidoptera. The species is a striking form both in structure and in color, with long thick light yellow antennae reaching beyond the tips of the yellow and purple wing. The species is common and well known in Europe, the larva feeds under a slight web on the under side of oak, beech, apple and pear. The species has hitherto been recorded only from Central and South Europe and from Asia Minor and the occurrence in British Columbia is difficult of explanation. Mr Busck had assured himself of the identity of this European and American specimen by careful slides of the male genitalia.

During the discussion Mr BUSCK mentioned two other Oscophorid species, *Borkhausenia pseudospretella* Stainton and *Endrosis lacteella* Schiffemuller, both common to Europe and to the West Coast of North America—in fact, both nearly cosmopolitan, but not occurring in eastern United States. Both these species are scavengers on stored seeds and refuse and are more or less domestic in their habits.

Dr. A. C. BAKER stated that certain European plants are found in restricted localities in British Columbia and not elsewhere in North America.

Mr. WM. MIDDLETON presented a note on *Adult feeding and its effect on the longevity of* Dibrachys (Pachyneuron) nigrocyaneum *Norton*. In the study of the life and seasonal history of *Diprion simile*, a recently introduced enemy of pine from Europe the advent of which species in America was noted by Mr. S. A. ROHWER in the June 1, 1916 meeting of the Society, a considerable number of a small chalcid parasite (*Pachyneuron*) *Dibrachys nigrocyaneum* Norton emerged from a quantity of cocoons in one of the general rearing cages. This parasite, which is an American species, was originally described from Connecticut where the cocoons from which it was this time reared were collected, and is recorded in *The hymenoptera of Connecticut*[1] as bred from cocoons of *Diprion abietis* and *D. simile*. The parasites were reared in the latter part of August, 1915, and *D. simile* was first discovered in this country at New Haven, Connecticut, in August, 1914.

[1] Connecticut Geol Natural Hist Survey, Bull 22

Among the experiments performed with these parasites several were conducted to obtain information on the longevity of the adults, with the following results:

Sixty-five adults were placed in vials without food, all the males dying within 3 days and the females within 8 days.

Forty adults were place in a vial with a piece of cotton soaked in sugar water; all the males died within 3 days but all the females, except 1, were living on the 13th day and all were not dead until the 17th day.

This experiment would seem to indicate that either the female alone took nourishment or at least they were the only ones to benefit by food with increased length of life.

Mr. ROHWER reported for the Executive Committee that the committee had decided on the National Museum as the meeting place, at least temporarily, and asked for an expression of opinion by the members. Several members expressed themselves as pleased with the arrangement.

335TH MEETING

The 335th meeting of the Society was held December 2, 1920, in Room 43 of the new National Museum building. Vice-President GAHAN presided and there were present 36 members and 3 visitors.

The Corresponding Secretary reported that he had been advised that the collection of cavern coleoptera secured from Austrian entomologists in exchange for food parcels had been sent. The collection contains 100 species representing many interesting genera not represented in the National Museum collection. The Secretary stated that these insects are to be accessioned as a gift to the National Museum through the Entomological Society.

Dr. H. E. EWING, of the Bureau of Entomology, and Mr. C. F. W. MUESEBECK, of Cornell University, were elected to membership.

Election of Officers for 1921

The officers for 1920 were re-elected. They are as follows: *President*, W. R. WALTON; *First Vice-President*, A. B. GAHAN; *Recording Secretary*, R. A. CUSHMAN; *Editor*, A. C. BAKER, *Corresponding Secretary-Treasurer*, S. A. ROHWER; *Executive Committee*, the Honorary President, E. A. SCHWARZ, the officers, and A. L. QUAINTANCE, A. N. CAUDELL, and E. R. SASSCER, *Vice-President* to represent the Society in the Washington Academy of Sciences, S. A. ROHWER.

Regular program

E. R SASSCER: *Quarantine work on the Mexican border.*

Mr. Sasscer prefaced his paper with some remarks concerning the early history of the Pink Bollworm in the Laguna District of Mexico, and the placement of inspectors at the main avenues of entrance along the Mexican border to prevent the entry of this insect in cotton seed concealed in freight cars and other vehicles, and in passengers' baggage. It was pointed out that at the present time the Federal Horticultural Board has twenty-four inspectors located at various ports on the Mexican border, and that fumigation houses of sufficient size to fumigate freight cars are located at Brownsville, Laredo, Eagle Pass, and El Paso. Two of these houses will accommodate from one to fifteen cars, one from one to six cars, and one from one to eight cars. At Del Rio, where there is at present no railroad connection between the United States and Mexico, a small house has been erected to fumigate wagons, automobiles, etc., requiring such treatment. He stated that steps were now

being taken to erect a fourteen-car fumigation house at Nogales, Arizona. 7,772 cars were fumigated as a condition of entry from October 1, 1919, to June 30, 1920. In addition to the fumigation houses, sterilization plants have been erected by private concerns at three of the principal ports of entry for the purpose of sterilizing, by the use of heat, corn arriving from Mexico. The arrival of corn fouled with cotton seed made it necessary to adopt this safeguard before permitting the entry of Mexican corn.

Reference was made to the inspection work conducted at the foot-bridges of the various ports, and it was indicated that living larvae of the Pink Bollworm had been intercepted on several occasions in cotton seed found in suitcases and in pillows. Other injurious insects not known to occur in the United States have been repeatedly intercepted. During the first six months of this inspection work there were no less than 1018 interceptions of contraband material Various phases of the work on the border were illustrated with lantern slides.

Notes and exhibition of specimens

Mr. R C SHANNON recorded the collection by himself on Moscow Mt., Idaho, of specimens of the peculiar fly, *Ambopogon hyperboreus* Greene, originally described and hitherto known only from Alaska near the Arctic Circle.

Dr. J M. ALDRICH discussed the use of caterpillars for food by the Pahute Indians of Mono Lake, California. The species used is found to be *Coloradia pandora*. The eggs are deposited on the bark of pine trees in the spring and hatch in midsummer The larvae feed on pine needles until cold weather and hibernate in the clusters of needles as small larvae. They finish feeding the following summer, pupate, and emerge the next spring. The life cycle, therefore, requires two years. The larvae are collected in very large numbers by means of trenches, placed on hot earth for about an hour, and dried in the sun. They are used in the making of soup. Other insects used as human food were cited by various members the pupae of the dipterous genus *Ephydra*, eggs of the hemipterous genus *Corixa*, etc. Other cases of two-year life-cycles in Lepidoptera were cited by Mr. BUSCK and Mr. HEINRICH, the latter attributing it in many cases to climatic conditions Mr. ROHWER spoke of the suspended development in a portion of the brood in certain saw-flies. He cited especially *Neodiprion lecontei*, which has two periods of emergence of adults from the same batch of eggs, one period in the spring and one in the fall from eggs the previous fall, and one in fall and one in spring from eggs laid the previous spring Mr CAUDELL stated that certain katydids and walking-sticks have two periods of hatching. Mr. MORRISON cited the case of the Coccid genus *Margarodes* in which life-cycles of 15–17 years are known.

336TH MEETING

The 336th meeting of the Society was held January 6, 1921, in Room 43 of the new building of the National Museum. President WALTON was in the chair and there were present 32 members and 3 visitors. The Editor, Dr. A. C. BAKER, reported that the contract for the printing of the *Proceedings* for 1921 had been awarded to the McQueen Co., of Washington. As chairman of the Auditing Committee, Mr. CAUDELL reported the accounts of the treasurer correct.

The Corresponding Secretary-Treasurer, Mr. S. A. ROHWER, presented his report for 1920, the tenth year of his tenure of office, including his report as

custodian of literature. After hearing a report by Mr. ROHWER on the results of the conference between the house committee of the Cosmos Club and representatives of the scientific societies, regarding the rental of the hall at the Club, the Society voted to continue to meet at the National Museum.

As a delegate representing the Society at the dinner given by the American Association of Economic Entomologists at Chicago on December 20, 1920, President WALTON reported a very profitable and enjoyable occasion, listing the representatives of the various entomological societies of the United States and Canada.

Regular program

W. R. WALTON: *Entomological drawings and draughtsmen, their relation to the development of economic entomology in the United States.*

This was a historical account of the artists who have added so much to the value of entomological publications since the beginning of entomology in America. Especial attention was given to those who illustrated the earlier works. This paper is to be published in the *Proceedings*.

R. A. CUSHMAN, *Recording Secretary*.

SCIENTIFIC NOTES AND NEWS

The Division of Graphic Arts of the National Museum has installed an exhibit showing the materials and processes involved in the manufacture of hand-made paper. The exhibit was presented by Mr. DARD HUNTER, of Chillicothe, Ohio, one of the few makers of hand-made paper in America.

The Petrologists' Club met at the Geophysical Laboratory on April 19. Prof. W. J. MILLER, of Smith College, Prof. R. A. DALY, of Harvard University, and Drs. N. L. BOWEN and P. ESKOLA of the Geophysical Laboratory, discussed *The origin and structure of the Adirondack anorthosites.*

A Mathematics Club has been organized at the Bureau of Standards by members of the staff. Dr. F. D. MURNAGHAN addressed the Club on March 28 on *Relativity and vector analysis; modern methods in vector analysis.*

The collections in the Division of Physical Anthropology of the National Museum have been enriched by an important accession. Dr. EDWARD A. SPITZKA, formerly professor of anatomy at Jefferson Medical College, Philadelphia, and for many years a student of brain morphology, has donated to the Museum his complete collection of brains of distinguished persons.

Dr. E. Q. ADAMS, of the color laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, has resigned to accept a position at the Nela Research Laboratory of the General Electric Company, Nela Park, Cleveland, Ohio.

Mr. LINCOLN ELLSWORTH, of New York City, has forwarded to the National Museum a 193-kilogram iron meteorite from Owens Valley, California.

Dr. REID HUNT, formerly of the Hygienic Laboratory, now professor of pharmacology at the Harvard Medical School, has been appointed a member of the advisory board of the Hygienic Laboratory of the Public Health Service, to succeed the late W. T. SEDGWICK.

Mr. ECTOR B. LATHAM, hydrographic and geodetic engineer with the U. S. Coast and Geodetic Survey, died on April 7, 1921, at New Orleans, where he was in charge of the Survey's local station. Mr. Latham was born in McMinn County, Tennessee, June 9, 1864. He was appointed assistant at the Survey in 1895, and had been in the service since that date, engaged in triangulation and topographic, photo-topographic, hydrographic, and magnetic work. He took part in the Survey's work in the Philippine Islands, and was with the first expedition to the Mt. St. Elias region in Alaska. He was a member of the Society of Engineers.

Mr. B. H. RAWL, assistant chief of the Bureau of Animal Industry, U. S. Department of Agriculture, has resigned, effective April 30, to take charge of the educational work of the California Central Creameries, with headquarters in San Francisco.

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CHEMISTRY.—*Note on the ice crystals which form on bare soils and on the stems of plants.*[1] VICTOR BIRCKNER, Bureau of Chemistry. (Communicated by Edgar T. Wherry.)

The formation in frosty weather of ice crystals on certain soils and on the stems of certain plants early attracted the attention of scientists. The literature[2] on these very fascinating phenomena dates back about a century and contains many speculations as to the cause and the mode of formation of these structures. The explanations usually offered rest almost entirely upon physical grounds, it being assumed that the ice in question consists of pure frozen water. My own findings have shown that ice structures both from bare soil and from the stems of dittany (*Cunila origanoides*) contain organic material.

A quantity of ice crystals from bare soil was taken to the laboratory in a small tin pail. The well-known ice structures from *Cunila* stems were also gathered, practically free from dirt, in a glass vessel and taken to the laboratory. Both kinds of ice, after melting and filtering, yielded a colorless opaque solution. After evaporation of 100 cc. of each solution in a platinum dish, the residue was weighed and then ignited. From 100 cc. of filtrate from soil ice, 0 0032 gram of residue was obtained, yielding 0.0016 gram of ash. The same quantity of *Cunila* ice gave 0.0032 gram of residue, but only 0.0006 gram ash. While, therefore, the two filtrates contained the same amounts of stable solids, the proportion of the ash was much greater, and the amount of organic matter correspondingly smaller, in the case of the soil ice than in the ice from dittany. This may well be due to the fact that the *Cunila* ice can be collected without difficulty in a state of very high purity.

Some of the earlier observers of the ice formation on *Cunila* have, it is true, suspected the presence of a foreign substance in these structures. In their papers they state that they have tasted the ice, but,

[1] Received February 10, 1921.

[2] Among the most important references to this subject are the following· W. W. COBLENTZ, Journ Franklin Inst. 178: 589 1914, Monthly Weather Review 42: 490. 1914, Scientific Monthly 2: 334. 1916.· J. SACHS, *Lehrb Bot.* (4th Ed), 703 1872

finding it devoid of all flavor, they concluded that their suspicion had been unfounded. The low percentage figure of the organic matter present may explain the fact that it is imperceptible to the taste. However, if the ice is allowed to melt, the presence of the organic substance readily manifests itself to the eye through the pronounced turbidity of the solution. The organic substance is, therefore, probably of colloidal character. The question as to whether or not its presence in these ices bears any relation to the peculiar shapes of these structures is, of course, unanswerable at the present time. Our knowledge of the properties of colloidal organic substances is still too incomplete.

An attempt was made to obtain an idea as to the chemical nature of the organic substance present in these ices. Upon concentrating the opaque solution on the steam-bath, a yellowish brown fluid was obtained which had a pleasant odor, similar to freshly baked bread. With ferric chloride solution, a yellow coloration was produced. Permanganate solution, made slightly alkaline, was readily reduced with the formation of an aldehydic odor (not of benzaldehyde, however). Bromine solution was decolorized These tests would indicate an aromatic unsaturated compound The latter was tentatively assumed to belong to the styrolene group, of which cinnamic and cumaric acids are members. This assumption was strengthened by the following biological observation A solution of melted ice from bare soil, after thorough filtration, was kept in a cold storage compartment at a constant temperature of about 1° C After two weeks, on examining the liquid microscopically, I found it to contain a bacterium in what appeared to be practically a pure culture The liquid was turned over to Dr Edwin Le Fevre of the Microbiological Laboratory, who made a careful study of the organism In this connection, Dr. William J. Robbins has isolated from soil a bacterium which is capable of utilizing cumarin as a source of carbon [3] Dr. Robbins was kind enough to send us a culture of the bacterium, and the two organisms were subjected to a comparative study by Dr Le Fevre, who reported that the classification of both organisms should be the same.

From these observations, it would appear that the present physical explanations for the above-mentioned frost phenomena are inadequate and that they cannot be fully explained until the nature and the physical properties of the organic substance present in these ice structures have been elucidated.

[3] W J Robbins, Science, N S 44: 894 1916

BIOCLIMATICS.—*Intercontinental problems in bioclimatics; with special reference to natural and artificial distribution of plants and animals.*[1] ANDREW D. HOPKINS, Bureau of Entomology.

One of the most important subjects for the consideration of entomologists, botanists, general biologists and agriculturists in the past, and for the future, relates to the introduction of plants and animals from one part of the world to another. This subject is largely one of the relations between life and climate, with regard to the original home of a species, the environments under which it has developed, the range and limits of its natural distribution on one continent, the place of its artificial introduction to another, its establishment there, and its natural or artificial spread from the point of entry.

This address is concerned with some of the principles of the bioclimatic law, methods of application and results as revealed by a study, just completed, of the relations between the advance of spring in eastern North America and western Europe as based on certain phenological events that characterize a particular phase of such advance. This study was made in connection with, and as a preliminary to, a more comprehensive investigation of the relation of the law to the bioclimatic zones of the continents, as a key to solving some of the problems in artificial distribution of desirable plants and animals, in the belief that the true guide to success is to be found in zones of similar bioclimatic types

While the subject of the bioclimatic law and its application to research and practice has been discussed in papers before this Society, and in recent publications, it is apparent that some of the principles on which the law is founded, and some of the features in the system of application, are not generally understood Consequently there are skeptics as to the sound basis and the scientific and practical value that we claim for it, which is an excuse for repeating our interpretations.

The bioclimatic law is a law of life and climate as related to the geographical coordinates *latitude*, *longitude* and *altitude*. It includes, as one of its principles, an average, or constant, rate of variation with variations in geographical positions, as manifested by the advance of the seasons and coincident phenomena, and by the geographical distribution of living organisms and types of climate.

[1]Address of the retiring president of the Biological Society of Washington, presented at a joint meeting of the ACADEMY and the Biological Society on April 2, 1921 (Received April 12, 1921.)

In accordance with this law the country-wide average rates of variation in time, temperature, and distance, as related to periodical phenomena, geographical distribution, range and limits of zones, etc., are represented by the unit constants of 4 days to each equivalent constant of 1 degree of latitude, 5 degrees of longitude (or 1 degree isophane), 400 feet of altitude and 1 degree F. of the thermal mean. These unit constants are equivalent, one to the other, and, therefore, the terms of one unit may be converted into those of another as required in the computation and expression of results.

The application of the law to the study of any problem relating to life or climate in which the elements and data are subject to expression in terms of quantity, as to time, temperature, and distance, falls within the category of a mathematical concept of variable nature and, therefore, in the solving of bioclimatic problems, involves the determination of certain evidence and facts by mathematical methods.

Principles involved in the application of the law.—In this mathematical concept of the bioclimatic responses to the solar and other fundamental factors of control there are a number of basic principles, namely:

1. *The principle of geographical unit constants* which relates to rates of variation or gradients of time, temperature, and distance, with variations in geographical position.

2. *The principle of the isophane and altitude* in which the isophane is an expression of the combined unit constant of the latitude and longitude coordinates while the altitude unit constant is a measure of variation with elevation of a place above its sea-level isophane in terms of time, and equivalent units of feet, meters, thermal mean, etc. This principle is fundamental in the systems and methods of application of the law, because it serves to locate and designate a geographical position and to fix its unit value relative to another position designated as the base.

3. *The principle of the sea-level constant.* This represents a uniform element of the system of computation of tables of altitude, time or thermal constants in accordance with the unit constants of the law. Thus, the isophanes of a map or a table, unless otherwise designated, represent a sea-level base and all computations for altitude positions, unless otherwise mentioned, are to or from this base.

4. *The principle of the base station and base data.* This principle, in connection with that of the sea-level constant, serves as a central or basic element of a uniform system of computation and comparison

of quantities. Thus, the geographical position of a continental or intercontinental base station serves as the central unit or key from which, or relative to which, continental and intercontinental tables of sea-level, time, thermal or altitude constant quantities are computed as a basis for making predictions for any given isophane or altitude position on any continent of the northern and southern hemispheres. It also serves as a basis for the establishment of any number of regional and local stations as equivalent bases for the computation of regional or local tables of constants.

5. *The principle of the constant and variable.* This relates to the study of variability with reference to a "constant" as the measure of the relative intensity of the factors of variation. In other words, the variation of the variable from its "constant" magnitude, is the measure, in terms of time, temperature, and distance, of the intensity of the controlling influence from whatever source.

This principle is of fundamental importance because, like the declination of the magnetic needle from its normal position, which enables the surveyor to reach a desired point, the variations of a recorded quantity from its "constant" enable us to determine certain desired facts and evidence in comparative studies of the bioclimatic relations between geographical positions, countries or continents.

6. *The principle of equivalents* as related to equal unit values of certain elements of the law and of the system of application, such as the geographic unit constants, coincident dates in the events of different species, variations from the constant in equivalent terms of time, temperature, and distance; local base stations equivalent to the intercontinental base in conforming to a standard regional or local variation constant.

7. *The principle of the average or norm* as related to variable quantities.

8. *The principle or law of averages* as related to the compensation of errors in reported dates of events, temperatures, general computation of data, etc.

(Examples were given of predictions from records at an intercontinental base station at Kanawha Farms, West Virginia, for places in western Europe. These predictions consisted of dates for the advance of a certain stage of spring to a large number of places in the British Isles and in Germany as characterized by the date of the flowering of the English hawthorn, *Crataegus oxyacantha;* also predictions of bioclimatic or life zones of stations and places represented by

recorded dates of the hawthorn event and recorded normal mean temperatures. It is shown that when the predicted dates are compared with the recorded dates at the same places the variation of the recorded from the predicted gives a reliable guide to the relative difference between eastern North America and western Europe as related to the advance of spring by latitude and by the equivalents of latitude and longitude in accordance with the bioclimatic law.)[1]

It has been found that, for the same latitudes and a 4-year average, spring advances 13 degrees farther north in western Europe than in eastern North America or on the average is 44 days earlier in western Europe than in the same latitude in eastern North America

In a general comparison of the results of the study as to the relations between the predictions and the actual dates, etc., it is concluded that the significance of the results of this study, based on the phenological facts and evidence represented by the hawthorn event and by the thermal mean, is in showing not only the relations between eastern North America and western Europe, as to the relative advances of spring, but the general range of variations, of the recorded dates and thermal mean equivalents, from the dates, and from the thermal means, predicted from an intercontinental base. These results indicate, as nothing else has heretofore, the amount of regional and local difference in days to be expected for a spring event between a place in eastern North America and places in western Europe. Indeed, the greatest significance of these results is, that the predicted agree so closely with the actual recorded dates, at such a large number of widely separated stations in western Europe, that we may assume that it is practicable to predict dates for certain seasonal events in any given year or average of years for any place on the eastern continent and to do this from a recorded date of the same or equivalent event at the intercontinental base station at Kanawha Farms, West Virginia, and in many cases as accurately as they are usually observed and recorded.

The results relating to the prediction of bioclimatic zones represented by the recorded dates and thermal means are of special significance in indicating the zonal relations between eastern North America and western Europe and in showing that the law may be applied to the preliminary prediction of zones of equal adaptation to certain species and varieties of plants and animals, farm and garden crops, as a guide to the successful introduction of desirable species

[1] The address was illustrated with maps and tables which, together with a part of the paper, are omitted at the suggestion of the author.

and varieties and the prevention of the introduction of pests from one to another part of the world. These, together with the results relating to variations in equivalent days and to the variations of the recorded from a constant thermal mean, are new and represent new methods and principles. The preliminary prediction of minor bioclimatic zones represented by the meteorological stations of the British Isles and Germany is perhaps one of the most important yet attained from the study and application of the bioclimatic law. The close agreement between the zones and variations in days indicated by this method, as compared with those indicated by the phenological method for western Europe, together with the close agreement found between the predicted zones for North America and the Merriam life zones, are significant, not only in this agreement of results from two quite different methods and as related to two continents, but in opening a new field of research and practice of exceptional promise, in scientific and economic results, as related to a wide range of human interests.

The general results of this study of an intercontinental problem in bioclimatics should leave little or no reasonable doubt as to the fact of, and prevailing responses represented by, the bioclimatic law. Neither should there be any doubt as to its practical application to almost any problem in any branch of natural science which involves a consideration of the responses of living organisms and climatic elements to continental, regional and local influences, or to problems that require a measure of the relative intensity of the factors of variations as related to periodical manifestations and geographical distributions.

BIOCLIMATICS.—*Bioclimatic zones of the continents; with proposed designations and classification.*[1]—ANDREW D. HOPKINS, Bureau of Entomology.

The Major Zones are the Frigid, Temperate and Tropical, designated as Majors I, II, and III. These majors are divided into Minor Frigid, Minor Temperate, and Minor Tropical, and are designated by Arabic numerals, as follows:

I. Major Frigid Zone.—Arctic and Antarctic, and Alpine, with Minor Frigid 1, 2, 3 and 4 from the poles and from higher to lower altitudes.

[1] In connection with the author's address at the joint meeting of the ACADEMY and Biological Society (see the preceding article) these designations and classification of bioclimatic zones for the continents of the world were suggested. (Received April 12, 1921.)

II. Major Temperate Zone.—South and north of and below Major I with Minor Temperate 1, 2, 3, 4, 5, 6, and 7. South and north of and below Minor Frigid 4.

III. Major Tropical Zone.—South and north of and below Major II, with Minor Tropical 1, 2, 3, and 4. South and north of and below Minor Temperate 7.

This suggested system of designations and classification of the zones is put forward with the idea of replacing names based on geographical features or political divisions of one country, continent, or hemisphere with designations that would be applicable to any continental or insular area of both hemispheres.

The Minor Temperate 1 to 7, Minor Frigid 4 and Minor Tropical 1, are wholly, or in part, equivalent to the Merriam life zones as related to North America. Thus:

Minor Frigid 4 = Merriam's Boreal or Arctic-Alpine.

Minor Temperate 1 = Hudsonian; 2 = Canadian; 3 = Transition; 4 = Upper Austral and Upper Sonoran in part, 5 = Lower section of Upper Austral, Sonoran and Carolinean and upper section of Lower Austral, Lower Sonoran and Austroriparian, and represents a transition between 4 and 6; 6 = Lower Austral and Sonoran in part; and 7 = Gulf strip as a transition between Minor Temperate 6 and Minor Tropical 1 which latter = Merriam's Tropical.

The range and limits of the minor zones are characterized primarily by certain average ranges of temperature and, as related to world distribution, may be designated as terrestrial thermal zones. Each Minor Zone may embrace in its world-wide range many types of climate and life peculiar to certain regions, local areas and places. Therefore, while their numerical designations and relations are maintained throughout, each minor is subject to division into many recognizable sections and subsections; each characterized by some peculiar regional or local conditions as to life, climate, weather, and physical adaptation of the land to various types and associations of life.

In general the position occupied by a given place may represent the upper, middle, or lower section of a zone designated as follows: (—) lower, (—.) lower middle, (.) middle, (+.) upper middle, (+) upper; and (— +) the lower of one and upper section of another or the colimits of two zones, as (— 3 + 4) = lower 3, upper 4.

The index or characterization elements of the minor zones and their subdivisions into sections are many and varied. Some of the principal ones are the thermal index; life type and ecological index; the

isophane and altitude index; and the phenological index; each modified by topographic, geologic, soil, and other features so as to define local subdivisions, even down to specific places only a few rods or feet in extent which may represent an element or feature of distinction.

When we learn to recognize and properly interpret these various guides to the major and minor features of a bioclimatic zone, it will be an easy matter to determine not only what zone is represented by a given region and section of the country, but what section or minor element of a zone is represented by a given place on a given farm. Then we will realize all and far more than Dr. Merriam and others have claimed for the life zones as guides to the development of human welfare in food, health, and prosperity.

BOTANY.—*Two new species of* Bursera.[1] HENRY PITTIER.

The two new species of *Bursera* here described have been found by the writer in the course of study of the Central American material of this genus in the United States National Herbarium

Bursera panamensis Pittier, sp. nov.

Low tree or shrub; branchlets short, thick, glabrous, grayish, leaves pinnate, small, the rachis pubescent, 1 to 4 cm. long, narrowly winged between the two lower pairs of leaflets, more broadly so between the upper pair, leaflets 5 to 9, subcoriaceous, sessile or almost so, ovate to ovate-lanceolate, the lateral ones rounded, the terminal one acute at base and apex, serrate and slightly revolute on margin, sparsely hairy above, grayish tomentose beneath; flowers unknown, fruiting racemes pubescent, 2 to 3 cm long, sparsely branched; drupes pedicelled, glabrous, subglobose, 6 mm. long, the pedicels 5 mm. long, bearing at the apex the persistent calyx.

Type in the U. S. National Herbarium, no. 715171, collected near the salt works at Aguadulce, Province of Coclé, Panama, December 6, 1911, by H. Pittier (no. 4993).

This species belongs to the group of *Bursera tomentosa* (Jacq.) Tr. & Pl., with pedicellate flowers and membranous, serrate or crenate leaflets, these more or less hairy on both faces. It is called "almácigo de cruz" by the natives of Aguadulce. The fluid oleo-resin which distils from the trunk and the decoction of the young leaves are popular medicines, the first being used as a calmant and the latter as a diuretic.

Bursera verapacencis Pittier, sp. nov.

Small tree or shrub; branchlets short, at first densely hairy; leaves clustered at the ends of the branchlets, alternate, bipinnate at the base, pilosulous above, densely brownish-hairy beneath, up to 5 cm. long and 4 cm. broad, the rachis very slender and narrowly winged, pinnae and leaflets 17 to 23, the former 6 to 10, each with 7 to 11 pairs of leaflets, these sessile, ovate or oblong, entire, rounded at the base, subacute at the apex, 2 to 8 mm. long,

[1] Received February 11, 1921.

1.5 to 4 mm. broad; racemes axillary, few-flowered, up to 3 cm. long; flowers unknown, drupes pedicellate, globose, about 5 mm. long, glabrous, the rachis of the racemes hairy, the pedicels 3 mm. long.

Type in the U. S. National Herbarium, no. 858,992 collected between Salamá and Rabinal, Baja Verapaz, Guatemala, May 31, 1904, by O. F. Cook and C. B. Doyle (no. 283).

This species is closely allied to *Bursera gracilis* Engler, but differs in the greater number of pinnae and leaflets, in the hairiness of the latter, and in having the racemes much shorter than the leaves.

ZOOLOGY.—*The selection of family names in zoology.*[1] W. L. McAtee, Biological Survey. (Communicated by S. F. Blake.)

The principles upon which the names of families and higher groups in zoology shall be selected have not received much attention, chiefly, no doubt, for the reason that the problems of genera and species have been more pressing. Indeed before action can be taken by the International Zoological Commission (presumably to be reconstituted) it is highly desirable, if not necessary, that there shall be some crystallization of opinion on the point among zoologists.

The leading Codes of Nomenclature have little to say upon the subject, the most explicit rule being found in the Stricklandian Code of 1842.[2] It states that families should be named for "the earliest-known or most typically characterized genus in them" The A. O. U. Code, 1886, says that such names "take the tenable names of some genus, preferably the leading one." The Paris-Moscow Code, 1889–92, states that family names are formed on "the root of the genus serving as the type," a remark paraphrased in the International Rules (1913) as "the stem of the name of its type genus."

The A. O U. provision is intentionally vague; those of the last two codes mean nothing unless they are intended to be understood in the sense of the Stricklandian canon. Since, with the exception of the words "earliest-known" in the latter rule, none of these codes specifies a method of selecting "typical" genera of families, nor states what the preference shall be among competitors for the rank, references in them to the selection of family names are practically meaningless.

[1] This paper, prepared in its original form in 1918, was laid aside on the principle of "letting sleeping dogs lie," but recent contributions in Science showing the slumber to be effectually broken, a little more disturbance should do no harm. (Received March 2, 1921.)

[2] To save time reference is made to *N A. Fauna*, No 23, pp. 722–3 (1904), where Dr. T. S. Palmer has quoted, with references, the code clauses relating to family names.

Recently a set of rules has been proposed in *Science*,[3] the most important requirement of which is that "The type genus of a family or subfamily is the included generic group from the name of which the family or subfamily name was originally[4] formed, and is to remain the type genus irrespective of changes in its name." In other words, the name of the family changes with every change in that of the so-called type genus. Thus if a family or subfamily name had been based on the genus to which the rose-breasted grosbeak is assigned, in following all of the mutations of its type genus it would have been changed to conform with the 5 generic names listed hereunder, during the period that family names have been generally used in ornithological nomenclature: Guiraca, Hedymeles, Goniaphaea, Habia, Zamelodia; and in earlier periods the species has been referred to at least 5 additional genera The writer does not undertake to say whether or not this is an extreme case; at any rate it illustrates how the system might work.

The opposed method of selecting family names is basing each upon that of the oldest included genus. If for any reason the oldest name becomes unavailable the next oldest is used, and so on. It stands to reason that if the bases of family names are exclusively the oldest generic names, there will be fewer nomenclatorial casualties than if any later names are used. For the more recent the name the more likely it is to prove a homonym or synonym.

In the absence of definite rules on the subject, how has the selection of family names worked out in actual practice in zoology? Unquestionably the general practice has been to use family names based on the earliest available generic names. Whether they were deliberately selected from this point of view may be questioned, but the evidence is strongly that way, for as will be pointed out in the sequel the chances of general agreement upon family names having priority in themselves are very remote. To illustrate usage in the selection of family names we may cite the "Index Generum Mammalium,"[5] in which 159 of the accepted names are based on the oldest generic name (not preoccupied) or upon one of a group of names of the earliest year date, while 34 (chiefly of fossil groups) are not. Of the total

[3] Science, N. S. 52: 142–147. Aug. 13, 1920.

[4] Discussion later in this paper shows that it is by no means easy to decide where and when the family name was "originally formed." Priority in family names is not the comparatively simple matter that it is in generic names.

[5] T. S. PALMER, *N. A. Fauna* 23. 1904.

number of accepted family names 157 also have priority as such among family names cited in the work, which include only those originally published in approved classical form, but it is interesting to note that of 33 "oldest"[6] family names not used, 22 are displaced by names based on the oldest genera. In 3 cases the "oldest" family name based on the oldest genus is not accepted.

Of the family names of birds used in the A. O. U check-list[7] 63 are based on the oldest generic name, while 7, or possibly 8, are not. Without going into the matter statistically, the writer feels justified in stating that in entomology it has been a very general practice to found family names on those of the earliest available genera.[8]

The earliest genera certainly deserve consideration as bases for group concepts, if for no other reason than that they represent the first attempts to segregate groups in the families involved Genera were established before families and the older among them, in many cases, had as broad scope as modern families. After decades upon decades of effort, priority in generic names is now pretty well worked out and family names founded in each case on the oldest available generic name will be little subject to change. Working on this basis, we have a system that comprehends both the original selection of the name and its replacement if necessary

Under the type-genus system replacement of a family name is provided for, as the name once selected follows that of the type genus in all its mutations. But what of the original selection? In brief, the proposal is that the earliest family name shall be selected. What does this mean? In view of the facts of nomenclatorial history and practice, it means that every supergeneric group name (based on that of a genus) proposed since 1758 must be taken into consideration. These names for the most part have never been catalogued, and discovering priority among them no doubt would take years of research. Does it not seem we are invited into a new nomenclatorial game in which for years and years when the question is asked, "Who has the oldest name for this family?" there will pop up here and there zealous bookworms each shouting "I have it," each "I have it" portending a change in family nomenclature?

[6] Quoted because names cited in the work do not include vernacular and other names that are available for choice in selection of family names.

[7] *Check-list of North American birds*. American Ornithologists' Union. Third ed. (revised), 430 pp 1910

[8] *The Entomological Code* (NATHAN BANKS and A N. CAUDELL, 1912, p. 22,) rules that the root-genus for a family name should be "preferably the oldest."

In the search for earliest family names the following difficulties, among others, will be encountered. Names based on those of genera are understood in each case.[9]

1. Family nomenclature as such was not in general use until more than 50 years after the *Systema Natura*, therefore what are now considered distinctive endings need not be looked for in the earlier names of supergeneric groups; names of whatever endings will have to be considered.

2. Rank of supergeneric groups was not always indicated and certainly cannot be closely correlated as between diverse authors. Families and genera of various authors equal in scope modern orders and families. Names of every rank will have to be considered Any name for a group agreeing chiefly in composition with one that now is, or shall in future be, considered of family rank is on the eligible list. Opinion will enter largely into the decision as to whether there is a sufficient degree of coincidence

3. It is impracticable to choose between names set forth in the formal language of science and vernacular names. Van Duzee, who is quoted as a disciple of priority in family names and of the type-genus method, says: "It was my intention to follow Dr. Horvath's scheme in all its details but as the work advanced it was found necessary to abandon his plan to discard all names not strictly in latin form. His method would have thrown out a large number of groups founded by Amyot and Serville in their great work which is really the foundation of all our modern classification of the Hemiptera."[10] Here it may be added that in numerous well-conceived systems the family and higher groups were given vernacular names only; indeed, in some cases only numbers were used.

As between a family or subfamily name in classical form and properly used, a scientific-appearing name casually used, a vernacular name appearing in an evidently good system, and a vernacular simply in text, who is to be the arbiter? and who will accept his judgment?

4. It would appear that names of whatever form, whatever rank, whatever language, wherever proposed, in fact every supergeneric

[9] This restriction is necessary of course on account of the *ex post facto* rules in modern codes relating to the formation of family names Many names not based on generic names have been used for supergeneric groups, which in other respects are as logical and worthy of consideration as those embodying generic stems Such names are available for suborders and higher groups but for families, never. Our system of priority is indeed garnished with many an exception.

[10] *Check-list of the Hemiptera* . . *of America north of Mexico*, pp vi–vii 1916.

name since 1758[11] must be taken into consideration in the selection of family and subfamily names on the basis of intrinsic priority. A great part of these have never been catalogued; who is to do it? and how long will it be until we shall be reasonably secure against the resurrection of names which may supersede a family name anywhere in the system? Under this plan would not the way be opened up for an indefinite number of changes in family and subfamily names?

Will we not be much better off if we base our family and subfamily nomenclature upon a set of names, the priority in which is already almost completely worked out, than to adopt a rule compelling us to search out priority in another set of names hitherto largely neglected by bibliographers, and in which the problems to be met are more complex and confusing even than they are among genera?

In other words, the present view is that due to inevitable difference of opinion as to whether only latinized names of subfamily and higher groups shall be considered, or whether vernaculars shall be included; as to what are classical forms and what vernacular; as to whether all supergeneric names, regardless of the rank given by their proposers, shall be considered, and as to whether the groups defined agree well enough in scope with modern concepts—differences of opinion, we would repeat, as to all these controversial points, would seem to block attainment of real priority in subfamily and family names. If substantial justice cannot be done, and this would further appear certain because of the necessity of ignoring numerical systems and the probability that vernacular-named subfamily and family groups even if considered would not receive consistent treatment, why would it not be better to record attempts at higher classification, formal and informal, only in technical taxonomic discussions and not try to convey this history in connection with the names themselves?

We can fix family names by an automatic process, that of basing them on the oldest included genera. Authorities for the names (seldom cited under present practice) would of course be unnecessary, but credit or responsibility for family and subfamily groupings could be separately recorded and include not only the more modern *pro forma* efforts, but also the earlier ones, however crude.

With choice between an automatic method having nearly clear sailing ahead, and another beset by the complications as to priority here

[11] Unless indeed some other date be selected for the beginning of family nomenclature; substantial agreement upon which probably could not be obtained.

alluded to, there would seem to be no reason for hesitation, unless thorough-going application of the former method should involve an entirely disproportionate number of nomenclatorial changes.

As evidence on that score it may be said that if 159 out of 193 family names in a standard work on mammals and 63 out of 71 in another on birds are now based on the oldest genera (and undoubtedly these are fair samples), the percentage of change required to bring all family names into agreement in this respect is by no means appalling. On the other hand, the search for priority among possible family designations has hardly begun and we know not through what nomenclatorial upheavals pursuit of that policy might lead us.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

GEOLOGY AND HYDROLOGY.—*Geology and ground waters of the western part of San Diego County, California.* ARTHUR J ELLIS and CHARLES H. LEE. U. S. Geol. Survey Water-Supply Paper 446. Pp. 321, pls. 47, figs. 18. 1919.

The report treats of the physiography, geology, and ground-water resources of that part of San Diego County, Calif., which is drained directly into the Pacific Ocean, and includes a geologic map of this area. This region consists of a mountainous highland area, and a narrow belt along the shore characterized by broad flat-topped sea terraces. The mountains of the highland area are believed to be due principally to erosion, but differential crustal movements have also been largely effective in mountain building

Comparatively flat tracts, or "highland basins," some of them surrounded by steep mountain walls, cover many square miles within the highland area. These tracts lie in three belts parallel to the trend of the main drainage divide, and may be remnants of a peneplain, many other remnants of which are preserved as flat-topped mountains. Several faults, presumably of considerable magnitude, have been identified, and numerous others are suggested by topographic evidence.

The drainage pattern shows a tendency for the streams to follow parallel courses and to make rectangular changes of direction. The drainage basins are unsymmetrical. There are places in all the principal valleys where the bed-rock floor is deeply buried beneath detritus, and several of the principal streams, after crossing deep valley fill, flow through narrow rock-bottomed gorges.

Repeated submergence and emergence has been the dominant factor in the development of the physiographic features of the coastal belt. These features comprise several extensive and numerous small sea terraces, ranging in elevation from 20 to 1200 feet above sea level, and dissected by streams to depths as much as 200 feet below the present sea level. The major valleys in the coastal belt have wide, flat, gently sloping floors, bordered by very steep slopes or bluffs several hundred feet high. They contain deposits of valley fill as much as 200 feet in depth

The geologic formations exposed in the highland comprise igneous and metamorphic rocks most of which are considered to be post-Carboniferous and not younger than early Cretaceous Thick deposits of Quaternary alluvium occupy parts of the principal river valleys. In the coastal belt, sedimentary formations ranging in age from Cretaceous to Recent are exposed. Undifferentiated Miocene and Pliocene deposits, parts of which have been referred to in earlier literature as the San Diego beds, are designated as the San Diego formation

The portion of this report prepared by Charles H. Lee treats of the ground-water hydrology of the shallow water-bearing formations of the Pacific Slope of the county, and the utilization of ground water from these formations Complete precipitation records at 106 stations and a detailed map are presented Conclusions are drawn regarding the amount of rainfall in any season necessary to produce run-off and also the relation of rainfall to run-off. Evaporation observations are given and comparison made between evaporation from a pan floating on a large reservoir surface, and the reservoir surface itself, which indicate that there is little difference between the two. Data regarding soil evaporation and transpiration from mixed natural vegetation are also given.

Detailed physical descriptions are given of the largest ten underground reservoirs of the region lying in the principal river valleys, with detailed geological and other data. The conclusion is drawn that ground water in the San Diego County river valleys has very little movement and seldom occurs as underground streams, but occupies underground reservoirs. Similar data are also presented for other underground reservoirs of the region.

Tests of existing pumping plants of various types are presented, which, for working conditions on the farm, show pump and pumping-plant efficiency and cost of pumping for irrigation. The selection and installation of pumping machinery are also discussed. A. J. E. and C. H. L.

GEOLOGY.—*The origin of the faults, anticlines, and buried "Granite Ridge" of the northern part of Mid-Continent oil and gas field.* A. E. FATH. U. S. Geol. Survey Prof. Paper 128-C. Pp. 10 (75–84), pls. 3, figs. 3. 1920

The paper is an attempt to find a common cause for the more or less parallel or continuous alinement in a general N.-NE. direction of the buried "granite ridge" of Kansas, certain larger folds, and a line of en echelon faults in Oklahoma and Kansas. Beginning with the discussion of the belts of faults the author assumes that the Pennsylvania strata would be incompetent to transmit the stresses which produced the faults but that the deeper-lying rocks from the Mississippian limestones down into the pre-Cambrian would be. He shows that horizontal movement along deep-lying faults coinciding in position and direction with the belts of en echelon surface faults could produce them. He also shows that folds and lines of folds might result from vertical move-

ment along such deep faults, but admits that the folds in the region considered have characters which could not be accounted for in this way. The "granite ridge" which is overlain directly by Pennsylvanian rocks must have originated in late Mississippian or early Pennsylvanian time, perhaps by movement along one of these deep-lying faults. Successive movements along these lines at distinct periods have resulted in different effects at different depths. The origin of the assumed deep-lying faults is ascribed to pre-Cambrian mountain-building movements, as all subsequent movements in this Mid-Continent region are considered inadequate to have produced them. M. I. GOLDMAN

GEOLOGY.—*The Lance Creek oil and gas field, Niobrara County, Wyoming.* E. T. HANCOCK. U. S. Geol. Survey Bull. **716-E.** Pp. 32 (91–122), pls. 4. 1920.

The Lance Creek field lies in east-central Wyoming, west of the Hartville uplift which connects the Rocky Mountains and the Black Hills. It is probably separated from that uplift by a broad syncline Cretaceous and Tertiary formations from about 1660 feet below the top of the Cretaceous Pierre shale up to the Tertiary White River formation and Quaternary alluvium are exposed. The sinuous anticline from which oil and gas are being obtained, as represented on a map by 100-foot contours, has a dominant east-west trend but turns north at its east end and south at its west end. The total length of the axis is probably about 20 miles, the closure of the anticline about 1,000 feet. The north and west flank is steep with dips up to 27° but on the south flank the dips run from $2^1/_2$° to 5°.

Production is being obtained from what the author considers the Newcastle sandstone about 200 feet above the Dakota sandstone, around 3,500 to 4,000 feet below the surface. The yield of the principal wells ranges from 250 to 2,500 barrels of oil and from 8 million to 30 million cubic feet of gas per day. The author suggests testing deeper beds at least to include the Jurassic Sundance formation which he estimates could be reached, by a well located on the top of the anticline, at a depth of about 4,200 feet He also draws attention to the possibility of production from the Wall Creek sandstone which lies about 1,050 feet above the Newcastle sand. M. I GOLDMAN.

ENTOMOLOGY.—*The colonizing reproductive adults of termites.* T. E. SNYDER. Proc. Ent. Soc. Wash. **22:** 110–150. 1920.

This paper, which was presented to the Faculty of the Graduate School of George Washington University as part of the requirements for the degree of Doctor of Philosophy, summarizes the literature and the author's extensive field notes of the colonizing habits of the reproductive adults of white ants. The three types of reproductive forms are discussed in detail, the nymphs characterized, and methods of colonization described. The results of the breeding experiments and attempts at cross-breeding are set forth. A summary of the paper and conclusions drawn is given and the article concluded by a list of the literature cited. S. A. ROHWER.

ENTOMOLOGY. *The subfamilies of Formicidae, and other taxonomic notes.* WILLIAM MORTON WHEELER. Psyche **27:** 47–55. Figs. 3. 1920.

This short paper gives a phylogenetic tree of the various subfamilies of ants. It also includes descriptions of new genera and subgenera and some remarks on the digestive system. S. A. ROHWER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

843D MEETING

The 843d meeting of the Philosophical Society of Washington was held in the Cosmos Club, December 18, 1920, with President FARIS in the chair, and 52 persons present.

The first paper was by R. W. G. WYCKOFF, on *The determination of the structure of crystals*, and was illustrated with lantern slides.

An outline of the development of the methods thus far used serves to show the point of view from which the studies of the arrangement of the atoms in crystals have been carried out. The essential steps in this development are the experiments of Laue and of the Braggs, the determination of the arrangement of the atoms in some one crystal and the consequent measurement of the absolute wave lengths of X-rays. In nearly all of the structures which have been studied a procedure based upon the point of view of these experiments has been followed. This procedure consists in getting a limited amount of experimental data with the aid of one of the three existing methods of obtaining diffraction effects—the Laue method, the spectrometer method or its modification, and the method of powders. Bearing these experimental facts in mind, the analyst has tried to imagine some arrangement of atoms which will explain them. If he has succeeded in devising such a grouping, it is considered to be the structure of the crystal. This method of procedure is both cumbersome and haphazard and there is no means of knowing whether many other ways of arranging the atoms of the crystal under examination do not exist, all equally capable of explaining the data.

This method is to be contrasted with the general method for studying the structure of crystals which can be built around the theory of space groups. The results of this geometrical theory can be given an analytical representation which states in terms of suitable coordinates all of the positions in space that atoms in crystals can occupy. With its aid, and knowing the crystallographic symmetry, it is thus possible to write down in the case of any particular crystal, independently of any X-ray experimentation, all of the ways in which the atoms can be arranged Suitable calculation will give the kind of diffraction effects to be anticipated from each of these possible arrangements of atoms. The experimenter may then obtain, by whichever of the various methods will yield the desired information most readily, those data which the calculations show to be necessary to distinguish between the possible atomic groupings.

The second paper, by I. G. PRIEST and MABEL K. FREHAFER, on *The optical basis of Bittinger's camouflage paintings*, was presented by Mr Priest, and was illustrated with slides and with examples and copies of the paintings.

Viewed in daylight, or any illumination approximating to this, these paintings appear no different from other paintings of the same kind; but if viewed through a red glass, or in red light, the aspect of the picture is changed materially. A picture of the sea, with a wave breaking, shows under the red illumination, a mermaid rising from the wave. A summer scene in which

are depicted a tree and a house, beside a dam, is transformed by the change in illumination into a winter scene, with ice and snow. In another, the smoke screen from a battleship shows concealed a large American flag, and the inscription, "Victory." The picture of an airplane bearing a cross, the German insignia, shows up the concealed circle, insignia of the Allies. The portrait of a lady is completely transformed by the red light, into a landscape, with a horse and man in the foreground.

The explanation of these effects lies in the two kinds of paints that Mr. Bittinger uses. Any pair of these pigments is very well color-matched in daylight, that is, there are two dark greens, two light greens, two lavenders, etc. But one pigment of each pair reflects a considerable amount of red light, so that in red light one is a highlight and the other a shadow. In any painting the two color-matched pigments are applied, side by side; but that of high reflecting power in the red is so manipulated that a complete picture in this kind of paint is produced which is visible as such only when the ordinary pigments are darkened by the use of the red light.

Experimental demonstrations of the above phenomena were made. The spectral reflection curves of the several paints as determined at the Bureau of Standards were shown by lantern slides These curves have been published in the *Journal of the Optical Society of America*, September, 1920, p. 391.

The third paper, by I G PRIEST, on *A relation between color and spectral distribution of light*, was also illustrated with slides.

In a study of colors of the same quality evoked by stimuli of different spectral distributions the following rule has been found to hold If any two lights, however different in spectral distributions, evoke colors of the same quality the wave lengths of the centers of gravity of their spectral distributions are coincident.

This paper has been published in the *Journal of the Optical Society of America*, September, 1920.

The last two papers were discussed by Messrs. SILSBEE, TUCKERMAN, WHITE, LLOYD, FERNER, and SOSMAN.

844TH MEETING

The 844th meeting was held in the Cosmos Club, January 15, 1921, with President FARIS in the chair, and 58 persons present.

The address of the evening was by the retiring President, ROBERT B. SOSMAN, on *The distribution of scientific information.*

The paper was discussed by Messrs PAWLING, C A BRIGGS, FERNER, WHITE, BROOKS, CRITTENDEN, HUMPHREYS, WRIGHT, WILLIAMSON, BURGESS, WATSON DAVIS, and others. It has been published in full in the *Journal of the Washington Academy of Sciences* [1]

845TH MEETING

The 845th meeting of the Society was held in the Cosmos Club, January 29, 1921, with President FARIS in the chair, and 47 persons present. The following program was given

G BREIT: *The distributed capacity of inductance coils.*

The distributed capacity of inductance coils affects their behavior in electrical circuits. It changes the effective resistance and inductance of inductance coils. It is important for the radio engineer to be able to predict from the construction of the coil the influence of its distributed capacity. The

[1] This JOURNAL 11: 69–99 February 19, 1921.

paper dealt with the principles underlying the calculation of the effects of the distributed capacity and with the experimental verification of the calculation of these effects.

One of the effects due to the distributed capacity is the change in the apparent inductance of the coil. This change may be shown to be due to the fact that the current distribution in the coil is not uniform. On this basis a calculation of the apparent inductance was made and hence the "effective capacity" of a coil was derived.

Similarly the resistance of a coil was discussed. On account of the non-uniform current, distribution based on the definition of resistance used for the case of uniform current-distribution becomes inapplicable. The resistance of the coil is redefined in such a way that it can be determined experimentally and used to calculate the current in the coil when the coil is placed in a known electric field. The experimental verification of the conclusions derived was discussed.

A considerable portion of the distributed capacity of a coil is due to the capacity of the coil to ground. This capacity manifests itself when two condensers are used in series with each other and with the coil. The assumptions underlying a theory of these phenomena were discussed and the theory was shown to be verified experimentally.

J. H. DELLINGER and L. E. WHITTEMORE *Radio signal fading phenomena* (presented by Mr. DELLINGER, and illustrated)

When radio first began to be used for long distance communication it was noticed that signals were not transmitted as far during the day as during the night-time. It has also been observed that night signals using the shorter radio waves vary greatly in intensity from minute to minute.

More recently, since radio direction finders have come into use, it has been learned that great variations may occur in the direction of radio waves as they arrive at the receiving station during the transmission of signals from a given transmitting station.

These and related phenomena have been recorded from time to time in the literature, and various hypotheses have been brought forward in explanation. The phenomena are dependent upon a large number of variable quantities, such as the weather conditions, the nature of the country over which transmission occurs, the surroundings of the transmitting and receiving stations, and the method of handling the receiving apparatus. Only by a statistical study in which the results obtained simultaneously at a large number of receiving stations are collected and tabulated may reliable averages be obtained.

Such a cooperative study is being carried on by the American Radio League and the Bureau of Standards, tests being conducted in June and October, 1920, and January and April, 1921 In these tests from five to ten radio stations transmit signals in succession. These signals are received simultaneously at about one hundred receiving stations whose operators are provided with forms for recording the variation in the intensity of the signals as received.

The paper described the results of the tests so far conducted and proposed an explanation of the phenomena. This explanation associates the long-distance radio transmission accomplished at night with the boundary of the highly conducting outer portion of the atmosphere, which is also the origin of auroral disturbances. Fluctuations in intensity are probably caused by irregular absorption of the waves by masses of slightly ionized air through

which the waves travel in their course. The "fading" phenomena are closely associated with the strays or atmospheric disturbances which affect all radio communications. This paper will be published in the *Journal of the Washington Academy of Sciences.*

F. B. LITTELL: *The variation of latitude and the constant of aberration from four years' work with the photographic zenith tube at Washington.*

A brief account was given of the principles of the photographic zenith tube devised by Dr. F. E. ROSS. The average probable error of a single latitude for the four years 1916–20 was ±0.089 second. A curve was shown giving the path of the North Pole as deduced from a combination of the results of the Washington observations with the results of observations made at Greenwich with the Cookson photographic floating zenith telescope.

A value for the constant of aberration of 20.454 ± 0.008 second was deduced from the observations, and curves showing the Kumiro or *z*-term for the years 1916 and 1917 were shown. An analysis of the meteorological conditions showed that the *z*-term could not be accounted for by the barometric gradients

This paper will appear in full in the *Astronomical Journal.*

Dr. R. S. WOODWARD characterized the subject as most important; and regretted that there was not time for its full discussion

H. H. KIMBALL, *Recording Secretary.*

BIOLOGICAL SOCIETY

617TH MEETING

The 617th regular (41st annual) meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club on December 11, 1920, with President A. D. HOPKINS in the chair and 28 persons present.

It was announced that on May 15, 1920, the resignations of N. DEARBORN as Treasurer and A. WETMORE as Corresponding Secretary were received, and that F. C. LINCOLN became the new Treasurer and T E. SNYDER the new Corresponding Secretary.

Reports of officers and committees were received, and officers and members of the council were elected, as follows

President, N. HOLLISTER; *Vice-Presidents*, A. S. HITCHCOCK, J. W. GIDLEY, S. A. ROHWER, H. C. OBERHOLSER, *Recording Secretary*, A. A. DOOLITTLE; *Corresponding Secretary*, T. E. SNYDER; *Treasurer*, F. C. LINCOLN, *Members of the Council*, WM. PALMER, E. A. GOLDMAN, H. H. T. JACKSON, R. E. COKER, R. W. WILLIAMS.

618TH MEETING

The 618th meeting of the Society was held in the lecture room of the Cosmos Club at 8.10 p.m. on January 8, 1921. President N. HOLLISTER called the meeting to order with 62 persons present. On recommendation of the Council, Mr. E. G. RUNYAN was elected to membership.

The President announced the following committees: *Committee on Publications*, C. W. RICHMOND (Chairman), J. H. RILEY, T. E. SNYDER, F. C. LINCOLN. *Committee on Communications*, S. A. ROHWER (Chairman), C. E. CHAMBLISS, J. S. GUTSELL.

Informal communications

J. M. ALDRICH exhibited dried specimens of caterpillars of *Coloradia pandora* Blake, which are used as food by Indians in the vicinity of Mono Lake, California. The species has a two-year cycle. Feeding on the Jeffrey pine

as larvae, they descend at the end of the second summer to pupate. They are then caught, and thrown into a pile of hot earth. After partial cooking they are dried in the shade, and thereafter will keep indefinitely. The specimens shown were eleven years old. There is but one brood, and caterpillars can be taken only in alternate years.

Mr. DAVID FAIRCHILD spoke upon the edibility of certain borers with which he had experimented.

Prof. A. S. HITCHCOCK reported progress toward agreement among the various botanical codes. The desire is to unite the American and Vienna Codes and to agree upon the principle of types.

Regular program

L. O. HOWARD: *Some views of the fight in southern France last summer against the Moroccan locust.* (Illustrated.)

This locust lives all around the Mediterranean coast, and at times is threatening to vegetation, it was especially so in 1920 in southern France in the sheep pastures. The government detailed soldiers to assist farmers in the campaign against the locusts, the farmer furnishing lodging, food, and all materials In early morning when the locusts were comparatively sluggish, they were driven to the center of the fields where a flame was played over the mass of insects A poisoned mash could not be used on account of the scarcity and expense of materials Views were shown of the farm quarters, the fields and locusts, and the methods of fighting the insects.

Dr. Howard also availed himself of the opportunity to visit the home of HENRI FABRE, at Avignon. The home is kept by one of his daughters exactly as left by Fabre at his death, five years ago. Fabre was very active to the time of his death, and in his garden there remain many plants which he brought from the Alps Views of the house, garden, and the medal which was struck in commemoration of the esteem in which Fabre is held by the French were shown

S F. BLAKE *Sexual differences in coloration of the spotted turtle.*

This paper will appear in full in the *Proceedings of the U. S. National Museum.* It was discussed by Drs. SHUFELDT and HOWARD.

A. A. DOOLITTLE, *Recording Secretary*

BOTANICAL SOCIETY

149TH MEETING

The 149th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 p.m , February 1, 1921, with 118 members and guests present, and President CHAMBLISS in the chair. Among the guests were Prof H. W. ANDERSON, of the University of Illinois, Prof F D FROMME, of Virginia Polytechnic Institute, Prof. J. F. COLLINS, of Providence, R. I , Dr RUDOLPH KURAZ, Secretary, Czechoslovak Legation, Dr DOBROSLAV TODOROVIC, Agricultural attaché from Serbia, and Mr. SOREN SORENSON, Agricultural attaché of Denmark. Mr. JOSEPH W. WELLINGTON was elected to membership.

Brief Notes and Reports of Literature

Dr. C. L. SHEAR called attention to an article in *Science* concerning the formation of a committee of 14 by the British to aid men of science in Russia, the main idea being to provide literature for Russian scientists. The meeting instructed the Executive Committee to give attention to the matter of providing scientific literature to Russian scientists, and instructed the So-

ciety's representative, Dr. HITCHCOCK, to bring this to the attention of the Washington Academy of Sciences

Mr. PIERCE called attention to the series of articles by Dr. JOHN HARSHBERGER, which began to appear in the October, 1920, number of the *Garden Magazine* on *Old gardens of Pennsylvania*. These articles dealing with the early botanists of Pennsylvania and their collections should be of interest to all students of botanical history.

Mr. LEWTON called attention to the new edition of Dr. MARCELLE HARDY'S *Geography of plants*, a copy of which was passed around for inspection.

Regular program

H. L. SHANTZ. *Natural vegetation of Africa.* (Illustrated with lantern slides.)

The vegetation of Africa ranges from the absolute desert of the southwest coast and portions of the Sahara, through desert shrub, desert grass, desert grass and acacia, and acacia tall grass to the great tropical savannas and in the Congo basin to the tropical rain forests, as higher elevations, mountain grass land and mountain forests appear. The distribution of these more important types was outlined and the agricultural potentiality of the land occupied by each type discussed and compared with somewhat similar types in the United States. Much of Africa is high, cool and dry, and is occupied by desert or semi-desert types, and only a relatively small portion by tropical jungles. The more important agricultural crops are corn, cassava, grain sorghums, bananas, beans and rice

IVAR TIDESTROM. *Notes on the flora of the Iberian Peninsula.* (Illustrated with lantern slides.)

The flora of the Iberian Peninsula is richer in species than any other of the European floras. The reason for this great wealth of species is the geographical position of Spain, the high elevation of the land surface above the sea-level, the various mountain ranges, and the proximity to Africa.

The littoral from Lisbon to Valencia, including the valley of the Guadalquivir, is semi-tropical, and appears to be analogous to the Pacific Coast region from San Francisco southward to Arizona, including the valleys between the Coast Range and Sierra Nevada. The Castilian and North African plateaus have a great number of plants in common, which fact tends to prove that there was a land bridge between the two continents at some remote time—a fact already noted by paleontologists

The meteorological conditions of these plateaus show resemblances to those of the southwestern United States where the minimum temperature does not fall below —17° C The general aspect of the plateaus and mountains is that of our western country, and the types of plants are similar. The upper belts of the mountains in Spain have a northern flora typical of the aspen, spruce, and alpine belts of the Rocky Mountains and Sierra Nevada

The cultivated plants of Spain thrive equally well in our southwestern states. Of the trees in cultivation, the Lombardy poplar is the most interesting. Community planting of this tree has been attempted in northern Spain, where plantations now exist for the purpose of supplying timber and pulp.

R. G. PIERCE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Messrs. WILLIAM BOWIE and H. G. AVERS went to Ottawa, Canada, in March, to consult with the superintendent of the Geodetic Survey of Canada in regard to the coordination of precise-level nets of the two countries. It is proposed that the two nets be adjusted together in order that the elevations on the boundary may agree in the maps and reports published in the two countries.

Prof. F. W. CLARKE of the U. S. Geological Survey, and Dr. H. S. WASHINGTON of the Geophysical Laboratory of the Carnegie Institution of Washington, have been elected Fellows of the Geological Society of London.

Messrs. HIPPOLYTE COPAUX, of the School of Industrial Physics and Chemistry of Paris, PIERRE LELAUDOUX, of the Tunisian Phosphate Company; EUGENIO DONEGANI, of the Sicilian Sulphur Company; and GEORGES FLUSIN, of Grenoble, visited the scientific institutions of Washington in April. They are in the United States to make a study of the fertilizer situation.

Mr. WILLIAM VALLEY HAGAR, junior hydrographic and geodetic engineer in the Coast and Geodetic Survey, died at Tarrytown, New York, March 24, 1921. Mr. Hagar was born March 25, 1888, at Weybridge, Vermont. In 1912 he was appointed an assistant engineer in the United States and Canadian Boundary Service and was transferred to the Survey in 1913.

The will of the late Miss CAROLINE HENRY, daughter of Professor JOSEPH HENRY, first Secretary of the Smithsonian Institution, gives $1,000 to the Institution and names it as residuary legatee of an estate with provision for several beneficiaries during their lifetime.

Dr. A. S. HITCHCOCK of the Smithsonian Institution left Washington in April for a trip to the Philippine Islands, Japan, China, Indo-China, Singapore, and Java, for the purpose of studying the bamboos. He expects to be absent about eight months.

Mr. DOUGLAS KARR, junior hydrographic and geodetic engineer in the Coast and Geodetic Survey, died at his home in Passaic, New Jersey, March 20, 1921. Mr. Karr was born in New York City March 1, 1891, and was appointed an aid in the Survey in 1913. He was retired on account of physical disability only a short time before his death.

Mr. A. H. MILLER, of the Dominion Astronomical Observatory of Canada, is at the U. S. Coast and Geodetic Survey engaged in a determination of the Washington periods of a set of pendulums for the purpose of determining the difference in the constant of gravity between Ottawa and Washington. This determination is to supplement and strengthen a determination of the difference in gravity between the two stations made just before the War.

Mr. WILLIAM PALMER, taxidermist in the National Museum, died on April 8, 1921. He had been connected with the Museum since its earliest days. The numerous specimens, both casts and mounted animals, in the exhibition series testify to his skill. The exhibit of the vertebrates of the District of Columbia in the National Museum is almost entirely his work.

Dr. H. S. WASHINGTON of the Geophysical Laboratory, Carnegie Institution of Washington, has been elected a foreign honorary member of Videnskabs Selskabet i Kristiania (the Norwegian Academy of Sciences) in the section of geology, mineralogy, and physical geography. The other American members are W. M. DAVIS and J. F. KEMP.

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RADIOTELEGRAPHY.—*Radio signal fading phenomena*.[1] J. H. DELLINGER and L. E. WHITTEMORE, Bureau of Standards.

INTRODUCTION

In actual communication by radio, many difficulties are encountered that would not be expected by one who is familiar only with the rather precise and clear-cut theory of the subject in books. Some of the phenomena in radio-frequency circuits may be represented accurately by ordinary alternating-current theory, the mathematical treatment being even simplified at radio frequencies. However, the phenomena of transmission of radio waves from one place on the earth's surface to another are of quite a different kind, and involve so many variables that they are very difficult of analysis.

The difficulties which are peculiar to the transmission and reception of the waves in actual radio communication may be divided into (1) "fading" or "swinging" of the received wave intensity, (2) strays; and (3) interference from other radio stations whose signals it is not desired to receive.

"Fading" is the rapid variation of intensity of the signals received from a given transmitting station, all circuit arrangements at the transmitting and receiving stations remaining constant. It is characteristically a night phenomenon.

"Strays" are electrical disturbances giving rise to irregular interfering noises heard in the telephone receivers of a receiving circuit. They are present in some degree at all times, though they are usually worse at night and in the summer time.

Interference from other stations differs from the other phenomena in that it can be eliminated. The means by which this may be done

[1] Presented before the Philosophical Society of Washington, January 29, 1921. Published by permission of the Director, Bureau of Standards. Received May 5, 1921.

are. (*a*) frequency selection, (*b*) selection of wave direction, and (*c*) guiding the waves along a channel; for example, along a wire. It is interesting to note that the first and last of these means for eliminating interference are also used in sound, while the second, the selection of the direction, cannot be used in sound, since sound waves are longitudinal while the electric waves are transverse. The matter of station interference will not be discussed further in this paper.

In regard to fading and to strays, a considerable literature now exists, much of it being contradictory The present authors have attempted to coordinate some of the outstanding and fairly well established facts, and to present recent results Because of the complexity and uncertainty of many of the phenomena, exceptions can be found to almost all generalizations

Complexity of the problem—The following four functions are characteristic of radio reception:

Intensity of received signals
Fading of signals
Direction of signals
Strays

In order to determine the facts regarding these functions, from the analysis of which the causes might be determined, research has to be undertaken to determine their behavior with respect to the following variables

Frequency of wave,
Kind of wave (as continuous or damped),
Distance,
Place (e g , sea, sea-shore, plain land, mountainous land, rivers),
Time (e g , day, night, sunrise, sunset, time of year),
Occurrence of eclipse,
State of solar activity,
Atmospheric electricity,
Terrestrial magnetism,
Miscellaneous (as discontinuities observed in space and in time)

These variables are by no means independent; for instance, the frequency and kind of wave affect differently the phenomena observed at various places and distances A complete study of the problem would require about 500 separate researches, each of them on a large scale The completion of some of these researches would cost millions of dollars The entire mass of data at present available can be considered as completing only a very few of these researches. The known facts about the variation of the four functions with a few of these variables will now be summarized. Following that, a theory will be given interpreting these facts.

EXPERIMENTAL AND OBSERVATIONAL DATA

Intensity of signals in day. (Variation with distance, place, and wave-length.)—The current in a receiving antenna is given by the following expression:

$$I_r \propto \frac{1}{\lambda d} e^{-\alpha \frac{d}{\sqrt{\lambda}}} \qquad (1)$$

where λ is the wave-length, d is the distance from the transmitting station, e = 2.718 ...and α is a constant known as the absorption coefficient. Quantitative measurements by L. W. Austin and others have shown that signals transmitted in the daytime follow this law within about 50 per cent particularly for the longer waves (over 1000 meters). Variations in received current are associated with variations of the absorption coefficient α. It is a minimum for transmission over ocean water and varies greatly over land, apparently depending largely upon the nature of the ground over which the waves travel

It has been observed that city buildings obstruct short waves. There is some evidence that waves tend to follow water, thus traveling greater distances along the coast than inland, and following rivers very readily The Alps and other mountains are said by Schwartzhaupt to obstruct signals greatly by day, but little by night.

The intensity of signals received from a given transmitting station varies greatly from day to day. Very long waves, such as those from the Lafayette station in France, vary as much from day to day as they do between day and night Greater distances are covered by stations of a given power when transmission is along the Mississippi Valley than in other directions in the United States

For small distances, the factor containing the absorption coefficient in equation (1) is very nearly unity Within these distances (up to 200 miles in many cases), the intensities of signals during day and during night are about the same, over sea-water at any rate, according to Austin. In transmission entirely in mid-ocean, very little fading has been observed.

The absorption factor of equation (1) also approaches unity as the wave-length is increased Thus for a given distance long waves are absorbed less than short waves and the falling off in intensity with distance is less marked for long than for short waves.

Intensity and fading of signals at night (Variation with distance, place, wave-length and kind of wave.)—The average signal intensity is much greater at night than by day, and the fluctuation or fading

is violent at night, these tendencies being more pronounced the shorter the wave-length. Thus abnormally great distances are obtained at night by stations using short waves, even though the power employed is as small as one kilowatt. Signals from such stations in the north-eastern part of the United States have been heard across the Atlantic, and off the coast of South America, as well as across the North American continent.

The phenomenon of fading is much better known among amateurs than among commercial radio men because amateurs do most of their radio transmitting and receiving at night and they are limited by law to short wave-lengths The great fluctuations in the intensity of signals and the extraordinary distances of transmission at night which have been reported by amateurs have not been taken very seriously by professional radio men because there are so many difficulties with radio apparatus that reliable results are hard to get

What is probably the most comprehensive series ever made of co-operative transmission tests on the phenomenon of fading was conducted during the past year through the cooperation of the American Radio Relay League and the Bureau of Standards Transmission took place from stations at a number of points in the northwest quarter of the United States according to a prearranged schedule, and simultaneous records of received signal intensity were made by about one hundred specially appointed receiving operators. Through the hearty and enthusiastic cooperation of the officers and members of the American Radio Relay League it has been possible to obtain many thousands of these records and to gain a great deal of information which it would be difficult if not impossible to obtain otherwise without an enormous expenditure. The handling of the records made during these tests as well as many details of the management of the tests have been in the hands of Mr. S. Kruse at the Bureau of Standards. These tests have given an opportunity to confirm in a statistical way what had previously been the impressions received by operators and experimenters in the course of receiving signals for other purposes.

Fading of signals as well as signals of abnormal intensity are obtained only at distances beyond which the absorption has been found to be appreciable On 200 meter communication, fading is not often found within a distance of 20 miles from the transmitting station, but fading is usually found at a distance of 60 miles or more from the transmitting station.

Three kinds of fading are observed: (1) Fading or swinging having a period of swing of the order of one second or less. This is associated with a given transmitting station. (2) Fading having a period of the order of one minute. This is associated with a region which may be that of either the transmitting or the receiving station. (3) Fading having a period of the order of one hour. This is associated with a general direction of transmission or with a group of transmitting stations.

Signals from a given transmitting station may be received with violent fading by some transmitting stations and simultaneously with very small fading by others. Certain transmitting stations are heard very well by many receiving stations in all directions on some evenings, and heard by very few receiving stations or in only one direction on other evenings. A given receiving station usually "hears" certain transmitting stations with great fading and others with little fading.

Transmission wholly over water (both transmitting and receiving stations far from land) shows little if any fading, while a narrow strip of land intervening introduces fading, according to Nichols. Stations near the coast fade worse than inland stations.

For three successive nights, no short-wave signals were heard in Virginia, though signals 800 meters or longer in wave-length came in with usual intensity. The same phenomenon occurred one night a week later in Baltimore and the District of Columbia. Later on, the ninth radio district (the Middle West) suffered a similar blank. During the District of Columbia anomaly the atmospheric conductivity was very abnormal, changing from a very high to a very low value without a corresponding change in the atmospheric potential gradient. At 12:17 a m. normal conditions abruptly returned, transmission becoming very good.

Signals on long wave-lengths, up to 23,500 meters, show very little variation in intensity. There is little if any difference in the fading from continuous wave and from spark stations on any wave-length.

Strays. (Variation with place and time)—Strays are more intense in the summer than in the winter, and in the night than during the day. They are more frequent and more severe in the tropics than in temperate latitudes.

At a given locality most strays come from a given direction. For the northeastern part of the United States this direction is south or south west. Strays are much less common in mid-ocean than near

land, both by day and night. The change from day to night conditions is much more abrupt at sea than on land. Stray storms usually accompany convective weather.

On October 5, 1920, severe strays were observed by receiving stations in New England, and no New England short-wave transmitting stations were heard outside of that locality. Transmission elsewhere was excellent.

Direction of signals. (Variation with time, wave-length, distance and kind of wave)—Changes in the direction of the wave front of waves reaching a receiving station from a given transmitting station are observed only at long wave-lengths, but are especially marked with continuous waves. They are far more noticeable at night than in the daytime. On 15,000 meters enormous changes in direction are observed at night (as much as 90 degrees within half an hour), while the changes observed during the daytime are very small, seldom exceeding ten degrees On 1000 meters, direction changes as great as ten degrees are seldom observed

The readings of direction can seldom be made sharply while changes in direction are occurring Sometimes when it has been changing very rapidly it becomes impossible to determine on any direction, the direction-finder giving no indication of a minimum signal in any position The minima observable are less distinct at night than during the day All direction changes are greater at night than in the daytime

Direction changes are very small at very short distances from the transmitting station, are great at medium distances, and small again at very great distances from the transmitting station These facts have been observed particularly regarding signals from the New Brunswick, New Jersey, radio station

Eckersley states the belief that waves are refracted in passing from sea to land and vice versa Tests of radio compass stations indicate that those stations which receive signals entirely over water have no error.

Effects of sunrise and sunset. (Intensity, fading, strays, and direction. Variation with wave-length)—Great variations in the intensity of radio signals of all wave-lengths, even up to 15,000 meters, are observed at sunrise and sunset Such variations are especially noticeable when transmission is in an east and west direction.

Transmission is not as good between stations when the boundary between dark and daylight intervenes as at other times of the day.

It has been reported that at sunrise and sunset the shorter waves have the advantage over the longer ones in transmission across the Atlantic.

At sunrise or sunset at the sending or receiving stations the intensity of signals on long wave-lengths becomes abnormally great. On short wave-lengths, at sunrise at the receiving stations, the signals from distant stations merely become steadier for a moment before they suddenly become inaudible.

It is possible that the reported differences in the abilities of inland and coastal stations in the United States to receive transatlantic signals may be the result of differences in their relation to the line of sunrise or sunset.

Effects of time of year. (Intensity and strays.)—Signals from distant stations are much louder on winter nights than on summer nights. Signals become poorer in the spring and it is a question whether this is caused by vegetation, ionization, change in temperature, or other factors.

Strays are much less frequent and normally much less intense, in winter than in summer.

Effect of eclipses.—The occurrence of an eclipse has been found to improve signals, even when they pass only through the penumbra.

Effects of atmospheric electricity, terrestrial magnetism, solar activity. (Intensity.)—In contrast to its effect on wire telegraphy, an aurora has very little effect on radio, except possibly short-wave signals. On an auroral evening none of the usual western stations could be heard at Hartford, Connecticut, but that city did succeed in communicating with Boston, a thing which, curiously, is usually impossible On the day after an aurora a Chicago station copied signals from a station in Los Angeles.

An aurora is preceded by violent variations in the earth's magnetic field, and usually occurs during periods of great sunspot activity. An aurora would seem to be an extreme case of disturbance at or below the Heaviside surface, producing ionization and also strays.

The conductivity of the atmosphere is somewhat greater at night than during the day. The atmospheric conductivity decreases and the potential gradient increases at the ground level at sunrise and sunset.

Culver reports that when the potential gradient and the conductivity of the air fluctuate greatly, strays are intense. He reports also that the intensity of strays varies inversely as the solar constant

and directly as the intensity of the earth's magnetic field.

Over sea the electrical conductivity of the air fluctuates less and is more uniform from day to day than over land

Discontinuities in space and time. (Intensity and strays.)—It is found that some stations have great difficulty in establishing communication with other stations quite near them though they have no difficulty in reaching other stations much farther away. Stations in the neighborhood of Boston, Massachusetts, furnish examples of this. It has also been found impossible to transmit over 70 miles east from Hartford, Connecticut.

Silent zones, where signals cannot be heard from certain stations, are frequently found at sea, the most noted ones being along the coast or between two bodies of land.

Inland stations have been found to get copy when coastal stations cannot This may possibly be a sunset phenomenon or the result of the location of the stations with respect to sources of strays.

Stations less than a mile apart may differ radically in the intensity of strays observed and in the intensity of signals received from a given transmitting station

Meteorological effects (Intensity, fading, strays.)—A good radio night, that is, one when the signals are loud and the strays are weak, is usually cloudy or is preceded by a cloudy day. Fading, however, is not affected by clouds Transmission is usually good during and immediately after a rain storm.

While correlations between meteorological and radio conditions have been sought repeatedly, little proof of such correlations has been found

Indirectly, meteorological conditions such as temperature, convection, etc , at the earth's surface may somewhat affect the regularity of the boundary surface of the Heaviside or aurora layer, and may thus cause night strays and the disappearance of signals Thus the difference in temperature between land and sea may cause an effect extending far up into the air

The effect of weather conditions on the insulation of an antenna and the resistance of the ground are principally important in day transmission. The effect of weather conditions on ionization and on the boundaries of the ionized regions in the upper atmosphere are more prominent at night

During the October, 1920, fading tests conducted by the American Radio Relay League and the Bureau of Standards, it was observed

that fading was small, signals were good, and strays were weak when it was raining at the receiving station. (Cases of little fading, 17; medium fading, 18; severe fading, 9. Signals were weak 4, moderately loud 31, and very loud 7 times. Weak strays 24, medium strays 13, and loud strays 6 times.)

Clouds at the receiving station are conducive to good signals. (Weak signals 9, moderately loud 75, and very loud 17 times.)

It is possible that clouds blanket the upper air from the disturbances of temperature and other effects on the earth's surface.

DISCUSSION AND EXPLANATION

The complexity of the phenomena suggests that the causes are complex, so that no one explanation will fit all the observations. However, many of the more clearly established facts lend themselves very well to the explanation of the transmission of radio waves proposed below

Daytime transmission —The waves that travel along the earth's surface (roughly, the sliding waves), and not the waves in the upper atmosphere, are those which are utilized in the daytime. This is indicated by the formula given in equation (1) in which the absorption coefficient, α, varies with the character of the surface over which transmission takes place. It is a minimum for sea water, and is greatly dependent on land characteristics.

For short distances, short waves give the loudest signals, the absorption being negligible. For long distances, during the day time when formula (1) holds true, long-wave signalling is more efficient, for the absorption factor predominates and limits the transmission for short wave lengths.

During the day the waves which get up into the atmosphere can be considered as entirely absorbed by the upper ionized regions, known as the stratosphere. Thus the intensity of the transmitted waves depends on the ground conditions. This is borne out by the fact that day transmission over sea varies very little with time This is to be expected, because the sea exhibits entire uniformity in its effect on waves passing over it, thus tending to confirm the idea that ground conditions determine wave intensity in the daytime.

The idea that waves are retarded by ionization is a very old one Elihu Thomson and Fessenden, however, first localized the ionization on the ground, but it has since been assumed to have its seat at higher and higher levels. The ionization of the air, which is not nearly large

enough near the ground to produce any effect, becomes larger as the distance from the earth increases.

The extreme ultraviolet rays of the sun ionize the air, but these rays are entirely absorbed during their penetration of the upper atmosphere. In the daytime, ionization in the higher levels is therefore unquestionably much greater than at lower elevations. Fleming states that the conductivity of the air near the earth's surface is 100,000 times too small to explain the observed absorption of radio waves. The ionization of the upper atmosphere, however, is so very great that it is probable that the waves which penetrate into the higher parts of the air in the daytime are totally absorbed, and that the observed absorption of waves received at a receiving station is to be explained by the losses in the poorly conducting earth itself.

While the variations from day to day in daytime transmission may not be entirely a ground phenomenon, it seems probable that they are attributable to variations in ground conditions.

Intensity and fading of signals at night—The short radio waves on which signals are heard at great distances during the night must travel detached from the earth's surface, for along the surface these waves are highly absorbed. It is probable that they reach an upper surface of the atmosphere, which is so highly ionized that its electrical conductivity is far greater than that of the surface of the earth, and hence they can travel with relatively little absorption

The idea of an upper conducting surface between which and the earth's surface electrical waves would be propagated, antedates the use of radio for long-distance communication since it was considered by Fitzgerald in 1893 and by Heaviside in 1900. Considerations largely independent of radio phenomena suggest the following structure and boundaries of the atmosphere, as indicated in figure 1.

(1) The earth's surface, a relatively poor conductor.

(2) The troposphere, about 10 kilometers thick, within which are the causes of our meteorological phenomena, and an atmosphere similar to that which we breathe.

(3) A radioactive layer, separating the troposphere from the region above it. (The existence of this layer is not as well established as the others, nor is its existence so important in explanation of the radio phenomena.)

(4) The stratosphere, or isothermal layer, having a thickness of approximately 100 kilometers. The stratosphere is ionized in the

daytime but quickly loses this property by the recombination of the ions at night.

(5) The Heaviside surface, permanently ionized, and an almost perfect conductor.

The boundaries of these layers are obviously not absolutely horizontal surfaces. The stratosphere is ionized during the day only, the sun's rays being the cause of the ionization. The permanently ionized region above the Heaviside surface is the region of permanent aurora,

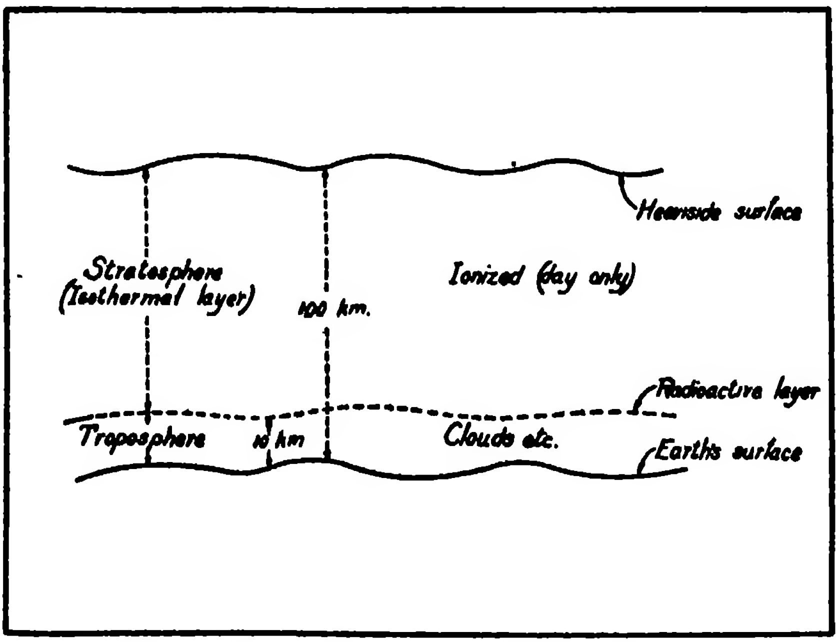

Fig 1.—Vertical cross-section of the earth's atmosphere

and is so good a conductor that the waves cannot penetrate it Any waves reaching it can only slide along it, just as waves slide along the even less perfectly conducting surface of the earth.

Previous explanations of radio transmission phenomena have considered the waves as being constantly reflected back and forth or progressively refracted between the Heaviside surface and the earth, both by day and by night, their intensity being reduced in the daytime by the ionization in the stratosphere. That view does not explain why the waves have the characteristics of ground absorption

in the daytime only, nor why they fade only at night. It seems more nearly correct to consider the daylight transmission of waves as being mainly along the earth as a guiding conductor, none of them being able to reach the Heaviside surface because of the intervening ionized stratosphere, while the waves at night reach the Heaviside surface and travel or slide along it without appreciable absorption

If this be true, then the waves should reach enormous distances at night, short waves traveling farther than long ones. Because of the variable absorption which may be introduced by the irregularities of the Heaviside surface and the adjoining regions, the waves may vary rapidly in intensity. Small irregularities would affect short waves more than long waves, hence short waves would fade most. These conclusions are in precise agreement with the facts.

Within the distance from a transmitting station in which ground absorption is negligible there is no fading and the night and day intensities are equal, since the waves are not affected by conditions in the upper atmosphere. If the theory given here be correct the maximum intensity of signals received at night should be that given by the transmission formula with the absorption factor equal to unity, and this has been observed to be true This should be taken as a standard transmission distance Certainly this is the only unique value, the only value in which the nature of the location of the transmitting and receiving stations does not enter Thus the transmission formula cannot predict the varying intensity of signals observed at night, but it does give the limiting value of signal intensity. It also shows why extraordinary ranges are more likely to be obtained at night with short waves than long waves.

This theory of night wave transmission is strikingly like the explanation of the flight of the projectile from the German long-range gun. In both cases it is now realized that there exists a region of the upper atmosphere of surprisingly low opposition or resistance.

G. Sagnac says that "zones of weak signals" observed between moving ships are due to the earth's orbital motion dragging the surrounding ether with it. It seems more probable, however, that such phenomena are caused by regions of exceptionally great absorption either of the wave transmitted along the ground or of the wave transmitted along the Heaviside surface, depending upon the conditions.

The relatively small fading on long wave-lengths is partly attributable to the fact that the transmission is along the ground.

If fading were to be explained by reflection and interference between the direct wave and the reflected wave it would seem obvious that fading will be greater in the case of continuous wave stations than spark stations, but apparently this is not the case. It seems probable that the reflection in the upper regions may more truly be considered a quasi-refraction resulting from an increase in the velocity of the waves as they enter the more highly ionized air.

Strays.—Of the several kinds of strays, some have their origin near the receiving station while others are waves sent out by electrical disturbances in certain definite regions such as the western part of the Gulf of Mexico or the central part of Africa Such regions are mostly tropical. The fact that strays are more intense at night than in the daytime is explained by the greater ease of propagation of all waves at night so that strays which are only local in their effects in the daytime spread to a distance at night.

The strays at night seem to be caused by occurrences at or above the Heaviside surface, because there are times when the strays are intense and yet signals are inaudible or very weak and fading violently This indicates a turbulent region of ionization over the area involved, which gives rise to strays and which absorbs waves that come into it. The aurora itself represents an extreme case.

Direction of signals.—There is no correlation between fading and direction changes except that both are greater at night Thus fading is greatest for short waves and direction changes are greatest for long waves. This makes it appear that the explanations of the two may not be closely related. The interference caused by waves from the Heaviside surface may explain the direction changes observed at night (rapid direction changes on long waves), as it is too remote to cause interference with short waves

Kinsley has suggested that the direction changes may be the result of reflection at the radioactive boundary between the troposphere and the stratosphere.

Effects of sunrise and sunset—The change from the ionized sunlight condition to the insulating condition of darkness introduces a surface of discontinuity which acts as an obstacle to the waves, partly reflecting them back. It is to be noted that the change takes place in the stratosphere, above the clouds. This deflection of the waves depends on a change in velocity of the waves, produced by the ionization. Since this change in velocity is proportional to the square of

the wave-length, the sunrise and sunset effects are greater for the longer wave-lengths.

Effects of time of year.—The increase of signal strength at night and the scarcity of strays in winter indicate that the Heaviside surface is more nearly level and encumbered with fewer masses of ionized air which are emitting disturbances. This more quiescent condition is probably a result of the sun's acting on the atmosphere for fewer hours each day.

Effects of atmospheric electricity, terrestrial magnetism, solar activity.—There is slight connection between radio phenomena and the usual variations of atmospheric conductivity and similar quantities at the surface of the earth. During intense strays and fading, the conductivity and potential gradient have been known to fluctuate more than usual. This indicates that the masses of ionized air that cause the radio phenomena have a slight effect extending down to the earth's surface.

The visible aurora seems to involve a lowering of the Heaviside surface far down into the stratosphere or even lower. It is known to extend down to about 60 kilometers above the earth's surface. This is done with much turmoil so that it usually stops short-wave radio altogether, or, if signals can be heard, the strays are violent. It completely upsets all usual radio conditions, in fact, in special cases it improves short-wave signal intensity over a certain territory, probably because in this case the lowering of the Heaviside surface envelops the usual source of disturbances.

Discontinuities.—While often difficult to explain, discontinuities are probably caused by some local ionization which acts like a barrier for that particular region. The fact that transmission is good for points beyond the silent zone substantiates the general theory of transmission of waves at night by the upper part of the stratosphere. In such a case they probably go around the barrier

The origin of this local ionization is unknown. Apparently some local condition on the earth's surface may cause it. It may be direct, as by radioactive emission, or indirect, as by extreme temperature differences or vertical convection currents in the air. Such indirect causes seem probable since there are many cases of discontinuities on or near the coast or in mountainous regions.

The cause of discontinuities is doubtless related to some sort of ionization change such as that accompanying sunrise and sunset.

CONCLUSION

It can be concluded that the causes or sources of fading and of strays are in the atmosphere between the earth's surface and the Heaviside surface. However, the origin of these causes, in turn, is undoubtedly from below the ground or from outside of the earth's atmosphere.

Daytime transmission is effected entirely by means of the waves carried along the ground, while night transmission, especially at great distances and on short waves, is by means of waves transmitted along the Heaviside surface. The latter, at night, are thus free from the absorption to which ground waves are subject in the daytime They are, however, subject to great variations, caused by irregularities in the Heaviside surface and absorbing masses of more or less ionized air at or near that surface. These variations account for fading.

The theory here given may be only a very rough approximation but it has the advantage of giving a clearer picture than has been available. The inter-relation of radio phenomena and the atmosphere's electrical condition is very close. Subordinate in importance to the atmospheric conductivity are the other electrical properties, the solar constant, and the terrestrial magnetic and meteorological conditions The properties of the stratosphere seem to be far more important than those of the troposphere, since the stratosphere seems to be the seat of the immediate causes of the observed radio transmission phenomena

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

GEOLOGY AND HYDROLOGY —*Ground water in Pahrump, Mesquite, and Ivanpah valleys, Nevada and California.* GERALD A. WARING. U S Geol. Survey Water-Supply Paper 450-C Pp 30, pls. 5, figs. 2 1920

The report comprises a geographic and geologic sketch and a discussion of the ground waters of the regions named. The valleys consist of detached basins with interior drainage, mountain-rimmed and deeply filled with alluvium. Alluvial fans slope from the mountain areas and grade into the playas which occupy the lowest portions of the basins. Springs occur in all of the valleys, and artesian flows have been obtained in Pahrump Valley Records of springs and wells are included in the report, and also a brief statement of the quality of the water. The extent of irrigation already practiced, the possibilities of further irrigation development, and the limits of agricultural projects are discussed. N. E. D.

GEOLOGY.—*Geology of Alamosa Creek valley, Socorro County, New Mexico, with special reference to the occurrence of oil and gas.* DEAN E. WINCHESTER. U. S. Geol. Survey Bull. 716-A. Pp. 15 (1–15), pls. 5. 1920.

This report is based on a field study of the coal resources of the region. Structure is therefore discussed only in a general way and not represented by contours. The geography of the valley lying between the Continental Divide on the west, smaller Tertiary mountain ranges to the south, and the Sierra Ladron on the east, is briefly described. About 8,000 feet of sedimentary rocks from Carboniferous to Recent are exposed. Carboniferous and Triassic represented by red beds are unconformably overlain by Cretaceous consisting of the Dakota sandstone at the base, with a series of shales, sandstones and coal beds overlying it. This upper series is divided into the Miguel formation roughly equivalent to the Mancos shale but more sandy, and the overlying non-marine Chamiso formation containing a Mesaverde flora. Unconformably on the Cretaceous lies the Tertiary Datil formation, largely volcanic with associated sandstones and conglomerates. Quaternary terrace gravels overlie all of these, and all formations except the younger terrace gravels are capped by lava flows. Structurally the area is the southeastern part of the San Juan Basin from the rest of which it is largely separated by the northwest trending Zuni Mountain uplift The prevailing dip at low angles to the west is interrupted by many faults and minor folds and cut by dikes, most of which trend roughly parallel to the Zuni Mountains As possible source of oil three larger anticlines are described, the largest 13 miles long. The presence of abundant carbonaceous shales, of coal with about 55 per cent fixed carbon, and of several massive persistent sandstones in the Miguel formation, which can be tested by holes less than 2,000 feet deep, afford favorable indications for the presence of accumulations of oil. The formations older than the Cretaceous may also contain oil accumulations. M. I. GOLDMAN

BOTANY.—*Another conidial Sclerospora of Philippine maize.* WILLIAM H. WESTON, JR. Journ Agric. Research **20**: 669–684. Pls 4, figs. 1. 1921

Another conidial Sclerospora is involved in the destructive maize downy mildew of the Philippines in addition to *Sclerospora philippinensis*, the casual fungus previously described. This second species, found in the Islands of Cebu' Bohol and Leyte, occuring commonly on maize, rarely on the wild grass, *Saccharum spontaneum*, and once on sugar cane, differs from *S. philippinensis* in that the conidiophores are generally longer and more slender, the basal cells are of much greater length in relation to the main axis, while the conidia especially are longer and less broad, and is described as new under the name of *Sclerospora spontanea*. These specific morphological differences remain constant even through several generations on a range of hosts, including maize, teosinte (*Euchlaena* spp.), *Miscanthus japonicus*, and *Saccharum spontanem* The size and shape of the conidia, the most valuable criteria of interspecific distinction, are given in detail, measurements of 700 conidia of each being presented in tables and graphs, and the more significant biometric constants being compared. Although morphologically distinct, the two species are alike physiologically in their effect on and in their virulence to the same host species. The probable relationship of the two fungi to the other conidial Sclerosporas of the Orient and to the oogonial stages of the Philippines is discussed. The occurrence of

Sclerospora spontanea on the wild *Saccharum spontaneume* is regarded as evidence that the disease has passed and is passing from this native host to introduced maize. W H W.

ENTOMOLOGY.—*The North American ichneumon-flies of the tribes Lycorini, Polysphinctini, and Theronini.* R. A. CUSHMAN. Proc. U. S. Nat. Mus. **58**: 7–48. Pl. 2. 1920.

This paper adds another to the series of papers revising the American tribes of the subfamily *Ichneumoninae* (*Pimplinae*). In it the genera and species are tabulated and described, and notes on the location of the types, biology of the species, and other valuable taxonomic information given in detail. As is usual for papers of this series, the host list and an index of the species treated is included Several text figures illustrating the structural characters and some drawings and photographs showing the habitus of the insects are added. S. A ROHWER.

ENTOMOLOGY —*New Serphidoid, Cynipoid, and Chalcidoid Hymenoptera.* A. A. GIRAULT Proc. U. S. Nat. Mus. **58**: 177–216 1920

This paper contains descriptions of new parasites which have been received for identification by the Bureau of Entomology. Most of the forms characterized are from North America and some few of them are known to be of considerable economic importance. S. A. ROHWER.

ANALYTICAL CHEMISTRY —*Sulphur in petroleum oils* C. E. WATERS Bur. Standards Tech. Paper **177.** Pp 28, fig 1 1920.

Short accounts are given of the theories concerning the origin of the sulphur and sulphur compounds which are found in crude petroleum. The forms of combination in which the element occurs, their identification and significance are briefly discussed. Tests for the detection of sulphur are described, and the copper test is shown to be one of great delicacy. Although it will show the presence of very minute amounts of free sulphur or of hydrogen sulphide, it may be of no value at all when the sulphur is in stable organic compounds. Various methods that have been used for the determination of sulphur in oils, and finally a new procedure, are described. The new method is based on the preliminary treatment of the oil with nitric acid saturated with bromine, followed by fusion with a mixture of sodium nitrate and carbonate.

Data obtained by the analysis of certain oils by this and other methods are given From these it appears that there is no loss of sulphur by the new method, which is recommended for laboratories which do not have a bomb calorimeter. C. E. W.

ANALYTICAL CHEMISTRY.—*An electrolytic resistance method for determining carbon in steel.* J. R. CAIN and L. C. MAXWELL. Bur. Standards Tech. Paper **141.** Pp. 24, figs. 6. 1919.

Method and apparatus are described for rapidly and accurately determining carbon in steel by absorbing in a solution of barium hydroxide the carbon dioxide resulting from direct combustion of the metal in oxygen, and deducing the carbon content from the change in electrical resistance of the barium hydroxide solution. J. R. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

619TH MEETING

The 619th meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club at 8.00 p.m., January 22, 1921, with President N. HOLLISTER in the chair, and 112 persons present. Upon recommendation of the Council, Mr. ARTHUR J. POOLE and Mrs. MARION G. BROWN were elected to membership.

Informal communications

Dr. PAUL BARTSCH stated that the Hiraci collection of Japanese and Pacific molluscs had been given to the U. S. National Museum. This with other large collections makes the collection of molluscs in the National Museum the largest in the world. Dr. BARTSCH also stated that a mocking bird was spending a third winter in his yard. It seemed to be the supply of water which is most appreciated.

Dr. R. W. SHUFELDT exhibited a file fish, part of a collection from Argentina, with an apparently abnormal file, it being double.

Dr. T. S PALMER, referring to the height at which birds fly, stated that W E. D. SCOTT at Princeton, and Dr. CHAPMAN telescopically observing birds crossing the disk of the sun, estimated their height at 10,000 feet Photographs of geese crossing the sun's disk yielded an estimate of 29,000 feet or about 5 5 miles. Direct observation from aeroplane has been made up to 10,000 feet

Dr. H. M SMITH made the first public announcement of the taking of the large forked-tailed swift, *Microperus pacificus* (Latham), upon the North American Continent The capture was made by Mr. G D. HANNA of the Bureau of Fisheries in the Pribiloff Islands.

Mr A. H. HOWELL stated that the crow roost at Laurel, Maryland, occupied for some ten years, has been abandoned for some other place farther north Dr L O HOWARD conveyed to the Society the greetings of former President Dr F A LUCAS, who was recently in the city.

Regular program

The speakers were introduced by Dr J. C MERRIAM, President of the Carnegie Institution of Washington.

L. H. MILLER, of the University of California *Asphalt beds of Rancho La Brea*

The asphalt beds, small and few in number, lie a few miles north of Los Angeles The asphalt has varied in viscosity from time to time, and has been in a more or less vertical circulation. Since Pleistocene times the beds have served as a constantly baited trap for all kinds of animals, and have gathered a characteristic fauna from that region in great numbers. Referring principally to the birds, Dr. MILLER said that, local as the deposits are, their richness and completeness threw light upon several large biological problems. (1) Questions of phylogeny. The deposits at Rancho La Brea show a very plastic condition of the genus *Haliaetus* in the Pleistocene. Many forms of bald eagles, some larger and some smaller than those now existing,

occurred, and out of this stock the present species seem to have crystallized. (2) Questions of homoplasy. A walking vulture, *Teratornis*, also a walking eagle, occur, both similar to *Serpentarius*, the secretary bird of Africa, but the former only superficially. (3) Questions of variability The great variability already referred to exists in other genera also, as in *Bubo* and *Cathartes*. Some forms of these were of tremendous size. Others such as the Californian condor, had reached more stable form (4) Questions of distribution. Many forms, now Central and South American in distribution, occur at Rancho La Brea. Thus the caracara and the black vulture, rare along the Californian border, are common. *Morphus*, the eagle hawk, and certain storks of Brazil and Argentina, occur in lesser numbers Here is found *Parapavo*, a peacock-like bird, forming a link, both in distribution and development, between the pheasants of the old world and the ocellated turkey of Yucatan and the turkey of the eastern United States (5) Indices of climate. Inferences from the present climatic distribution of birds, identical with or similar to those found at Rancho La Brea, indicate a climate more tropical than that of recent times, and supporting a vastly richer assortment of forms. The paper was illustrated with pictures of the asphalt beds and specimens from the beds, and restorations of the life and environment there in Pleistocene days.

H C. BRYANT, of the University of California *Birds and mammals of Yosemite Park.*

The speaker called attention to the changing distribution of birds during the day, or season, or with changes in weather. The white-throated swift, apparently on the wing all the daylight hours, feeds on the floor of the valley in the morning, later it flies at middle heights, and in afternoon only about the highest cliffs As the season progresses many birds spread from the breeding and feeding grounds of the valley to the higher hill region, such as the jay shrike, and kingbird On the other hand, storms in the highlands drive birds into the valley, such as the nighthawk Further notes upon many birds were given Protection to birds does not l ad in all cases to their increase This is true of grouse and quail, suggesting unsolved problems. Protection cannot be given to all animals alike. The interrelation between deer and panther is an example

The speaker emphasized the impossibility of appreciating the fauna and flora of Yosemite or other National Parks or Preserves without familiarity with nature in the field. The interest taken by young and old alike in studies afield of animals and plants justifies a greater development of the naturalist who can interpret the work of the specialist and make it accessible to the nonscientific public. The paper was illustrated by numerous views of Yosemite and of individual birds and animals.

The papers presented by Drs. MILLER and BRYANT were discussed by R. W. SHUFELDT, A. S. HITCHCOCK, DAVID WHITE, and J. C. MERRIAM.

A. A. DOOLITTLE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Pick and Hammer Club met at the Interior Department at 8 p.m. on Saturday, April 30 Prof. E. W. BERRY of John Hopkins University gave an illustrated talk on *Impressions of Peru and Bolivia.*

The National Academy of Sciences held its annual meeting in Washington, April 25–27. Sessions for the presentation of scientific papers were held at the National Museum on April 25 and 26. The following-named 15 persons were elected to membership FRANK MICHLER CHAPMAN, ornithologist, American Museum of Natural History, New York; WILLIAM LEROY EMMET, electrical engineer, General Electric Company, WILLIAM DRAPER HARKINS, chemist, University of Chicago; ALES HRDLICKA, anthropologist, National Museum; ARTHUR WILLIAM KENNELLY, engineer, Harvard University, WILLIAM GEORGE MACCALLUM, pathologist, Johns Hopkins Medical School, Baltimore, DAYTON CLARENCE MILLER, physicist, Case School of Applied Science, Cleveland, Ohio; GEORGE ABRAM MILLER, mathematician, University of Illinois, BENJAMIN LINCOLN ROBINSON, botanist, Harvard University, VESTO MELVIN SLIPHER, astronomer, Lowell Observatory, Flagstaff, Arizona, LEWIS BUCKLEY STILLWELL, electrical engineer, New York City, DONALD DEXTER VAN SLYKE, biochemist, Rockefeller Institute for Medical Research, New York City; THOMAS WAYLAND VAUGHAN, geologist, U S Geological Survey, HENRY STEPHENS WASHINGTON, geochemist, Geophysical Laboratory, Carnegie Institution of Washington, ROBERT SESSIONS WOODWORTH, psychologist, Columbia University

Mr ARTHUR E FATH returned to the U. S. Geological Survey on April 29, after several months' furlough

Dr. JOSEPH GRINNELL, director of the Museum of Vertebrate Zoology, Berkeley, California, was in Washington in May studying the ornithological collections at the National Museum

Mr O B. HOPKINS has submitted his resignation as geologist in the U. S. Geological Survey, effective April 1, to continue his work in the prospective oil fields of Canada.

Dr. ROBERT RIDGWAY, of the U. S National Museum, received the Daniel Giraud Elliot Medal of the National Academy of Sciences on April 26, for his studies of the birds of North America.

Dr. H. L SHANTZ, agricultural explorer of the Department of Agriculture, lectured before the Cosmos Club on April 25 on *Some experiences of a trip from the Cape to Cairo*

Mr. E W SHAW, geologist, resigned from the U. S. Geological Survey on March 30 to take up consultation work in oil and gas.

Dr. C. W. STILES, of the Hygienic Laboratory, U. S. Public Health Service, received on April 26 a gold medal of the National Academy of Sciences "for eminence in the application of science to the public welfare," in recognition of his work on the hookworm disease

Dr CHARLES D. WALCOTT, Secretary of the Smithsonian Institution, received the first award of the Mary Clark Thompson Medal of the National Academy of Sciences, for distinguished achievement in geology and paleontology. The medal was awarded at the meeting of the Academy on April 26.

Mr. ARTHUR R. WILLIS, chemist with the U. S. Tariff Commission, met death by accidental drowning in the Potomac River on April 24, 1921. Mr. Willis was a native of Ohio, and was 20 years of age. He was a member of the Chemical Society.

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MATHEMATICS AND BACTERIOLOGY.—*On the dilution method of counting bacteria.*[1] P. V. WELLS and W. F WELLS. (Communicated by S. W. Stratton.)

The dilution method of counting the number of bacteria in water is an example of the use of a geometric scale when the variations are so large that an arithmetic scale is cumbersome. We shall investigate briefly the theoretical basis of this method, with a view to the standardization of the experimental procedure, and shall show that its results have a remarkably simple interpretation.

FUNDAMENTAL THEOREM

Consider a "universe" containing A cc of water, and B bacteria. If a sample of α cc. is examined, the chances of finding n, $n-1$, 2, 1, 0 bacteria, respectively, in the sample are given by the terms of the hypergeometric series

$$\frac{B(B-1)...(B-n+1)}{N(N-1)..(N-n+1)}$$
$$\left[1+n\frac{W}{B-n+1}+\frac{n(n-1)}{2!}\frac{W(W-1)}{(B-n+1)(B-n+2)}+....\right] \quad (1)$$

where the water is conceived as composed of W "particles," giving the total "population" $N \equiv B + W$, and the sample contains n particles. Each particle, whether bacterium or water, is assumed to have an equal chance of being sampled. The general term, for the probability of finding C bacteria in the sample is

$$P_C = \frac{B(B-1)\ ....\ (B-n+1)}{N(N-1)\ ....\ (N-n+1)}$$
$$\left[\frac{n(n-1)\ ....\ (n-C+1)}{C!}\frac{W(W-1)\ ....\ (W-n+C+1)}{(B-n+1)(B-n+2)....(B-C)}\right] \quad (2)$$

But since the population N is arbitrary, this result is of little use as it stands.

Taking the population N as infinite, and n as extremely large, but small compared with N, and placing $X \equiv B/A$ as the number of bac-

[1] Received April 29, 1921.

teria per cc., we have $B/N = \alpha X/n$. Hence equation (2) reduces to

$$P_C = \frac{(\alpha X)^C}{C!} \exp(-\alpha X)\,* \tag{3}$$

which is the fundamental expression for the probability P_C of finding C bacteria in an α cc. sample of water containing X bacteria per cc. The sample usually taken is $\alpha = 1$ cc. From the form of the expression we have

$$\sum_0^\infty C(P_C) = 1 \tag{4}$$

as it should, to represent probability. The probability P_0 of a negative result, on plating out, is

$$P_0 = \exp(-\alpha X) \tag{5}$$

and of a positive result is $1 - P_0$. This reduces to McCrady's[2] result when $\alpha X = 1$, namely $1 - P_0 = 1 - 1/e = 0.63$

As there has been some misunderstanding of McCrady's work, perhaps due partly to the form in which it was expressed, a few remarks on the theory here given may be appropriate. The only assumptions are: (1) that in a large number of samples of α cc each, the bacterium considered is on the whole as often in one of the samples as in another (random distribution), and (2) that the presence of one bacterium in a sample does not affect the chances of the others being there (independent probabilities). These assumptions can hardly be doubted in this particular case, because one bacterium occupies about 10^{-12} cc., so that one million per cc. would occupy only one millionth of the volume. From studies of Brownian particles it is known that there are considerable fluctuations in density.

Now suppose the samples are diluted, β cc. in D cc. of water, then the probability of finding C bacteria in α cc. of the diluted sample is, from (3)

$$P_C = \frac{z^C}{C!} \exp.(-z) \tag{6}$$

where

$$z \equiv \alpha\beta \frac{X}{D}$$

* $P_C = \frac{(\alpha X)^C}{C!} e^{-\alpha X}$

[2] H. H McCrady. Journ Infectious Diseases 17: 183. 1915.

As a function of z, this equation is a special case of Pearson's Type III frequency curve, and the mode M_z, or most probable value of z is simply $M_z = C$.

"PER CENT NEGATIVE" METHOD

The quantities α and β are usually taken as 1 cc.($\alpha = \beta = 1$). The probability of a negative result (no bacteria) in the diluted sample is simply the negative exponential

$$P_0 = \exp.\left(-\frac{X}{D}\right) \tag{7}$$

This is the frequency curve of the negative plates in dilutions D. The mode ($M_D = \infty$), or most probable value of the negative dilution D is infinite, as it should be. The fraction of negative plates in dilution D is P_0, and the percentage of negative plates 100 P_0, when the number of samples taken is sufficiently large to overcome the fluctuations of sampling, and when there is no constant error in the experimental procedure.

In practice the sample (1 cc.) is diluted in the definite dilutions $D = 10$, 100, 1000, etc., cc of water, and P_0 observed. In order to compute X from these results, place in (7)

$$E \equiv \ln\left(\frac{1}{P_0}\right) = \frac{X}{D} \tag{8}$$

Then

$$x = d + e \tag{9}$$

Where

$$\left.\begin{aligned} x &\equiv \log X \\ d &\equiv \log D \\ e &\equiv \log E \end{aligned}\right\} \tag{10}$$

The arithmetic means $\bar{d}$ and $\bar{e}$ are therefore related by the simple expression

$$x = \bar{d} + \bar{e} \tag{11}$$

and the number of bacteria per cc. X is given by the product of the geometric means

$$X = G_D G_E \tag{12}$$

Where

$$\left.\begin{aligned} \bar{d} &\equiv \log G_D \\ \bar{e} &\equiv \log G_E \end{aligned}\right\} \tag{13}$$

The "per cent negative" method requires for convenient application a table giving e in terms of P_0, as in table 1.

It is evident from the magnitudes in the second column of table 1

TABLE 1

Per cent Negative $100\,P_0$	Correction e
5	0 48
10	0 36
15	0 28
20	0 21
25	0 14
30	0 08
35	0 02
36 8	0
40	0 96–1
45	0 90–1
50	0 84–1
55	0 78–1
60	0 71–1
65	0 63–1
70	0 55–1
75	0 46–1
80	0 35–1
85	0 21–1
90	0 02–1

that the arithmetic mean $\bar{e}$ in any actual case will be merely a correction to be applied to the "average log dilution negative" $\bar{d}$. The number of bacteria per cc., X, is therefore roughly equal to the geometric mean G_D of the numbers of cc. (D) into which the sample (1cc) is diluted. Its precise value is given by (12) which is used in the form (11)

The computation of the "log count" (x) is very simple. The dilutions are $D=10$, 100, 1000, 10,000, etc , and the corresponding "log dilutions" are $d=1$, 2, 3, 4, etc ; only those dilutions are chosen for which the "per cent negative" ($100P_0$) is between 5 and 90 per cent. The values of e are taken from table 1, and the sum $(d+e)$ recorded. The simple average of these figures gives x. The antilogarithm of x is the number of bacteria per cc. (X). The following examples illustrate the method.

Example 1

(20 samples, 3 negative in $D=10$ cc., 13 in 100 cc , and all in 1000 cc.)

d	Per cent Neg	$d+e$
1	20	1 21
2	65	1 63
		$x=1$ 42

$X=26$ bacteria per cc.

Example 2

(20 samples, 11 negative in 10,000 cc, all negative in 100,000 cc.)

d	Per cent Neg.	$d+e$
4	55	$z=3.78$

$$X=6\times10^{3}=6{,}000 \text{ bacteria per cc.}$$

To determine P_0 with precision, more samples must be taken at each dilution than is practicable for a single specimen of water, but the method is very useful where many bottles of water are collected, or where the samples represent a seasonal distribution. The use of the geometric mean in such cases is justified only by the type of such frequency distributions. This point will be considered in a subsequent paper.

METHOD OF BACTERIAL COUNTS

No information is gained in the "per cent negative" method from the number of colonies found on the positive plates. Returning to the fundamental equation (6), the probability of finding C bacteria in the diluted sample is

$$P_C=\frac{z^C}{C!}\exp.(-z) \qquad (6)$$

Now the bacterial counts are usually fairly large ($C>10$). In this case Stirling's formula gives

$$C!=C^C\sqrt{2\pi C}\exp\ (-C) \qquad (14)$$

Comparing (6) and (14),

$$P_C=\frac{1}{\sqrt{2\pi C}}\left(\frac{z}{C}\right)^C\exp.(C-z) \qquad (15)$$

This is the frequency curve of bacterial counts of a given sample (at a fixed dilution). The mode (M_C), or most probable value, of C is given by the condition

$$\frac{1}{P}\frac{dP}{dC}=\ln\frac{z}{C}-\frac{1}{2C}=0 \text{ (when } C=M_C) \qquad (16)$$

Neglecting $\frac{1}{2C}$ compared with $\ln C$, involving an error of 2 per cent when $C=10$, and less for larger values, we have

$$M_C=z=\alpha\beta\frac{X}{D} \quad (C>10) \qquad (17)$$

That is, when $\alpha=\beta=1$, the number of bacteria per cc. (X) is simply the product of the dilution D and the mode M_C of the frequency dis-

tribution of bacterial counts C as would be guessed from "common sense."

The frequency distribution (6) is mathematically very complicated. Its graph, represented in figure 1 for the values $z=10$ and 100 bacteria per cc., shows it to be nearly symmetrical about the mode, the

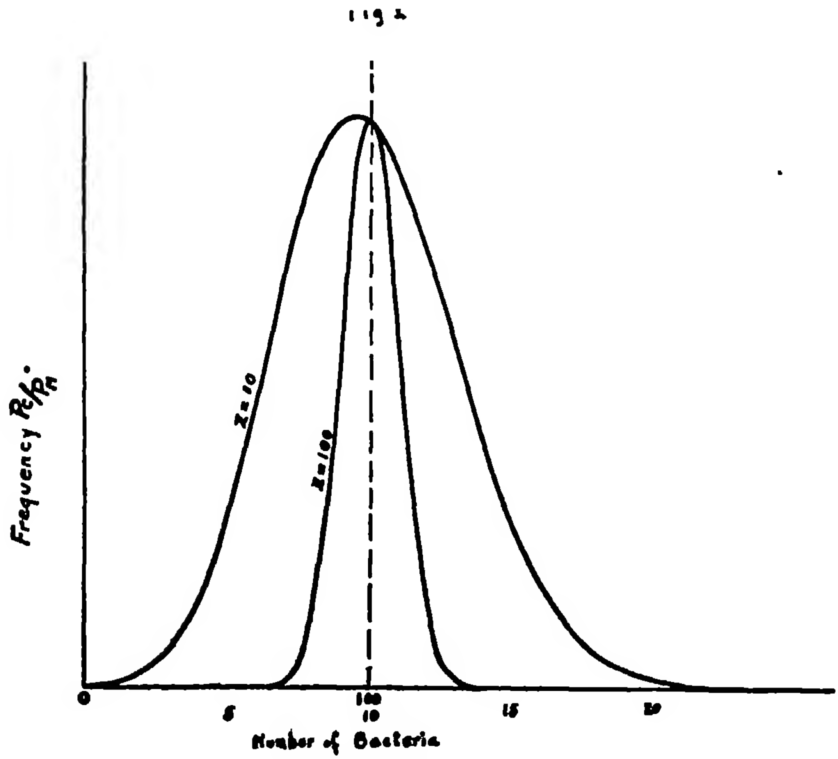

Fig 1.—Graph of frequency distribution

maximum becoming very accentuated as z increases. This is obvious from the variability of the curve, computed by Pearson's method of moments, and given in table 2 together with the other constants.

Thus the curve possesses the remarkable property that although it is unsymmetrical, the mode and the arithmetic mean coincide within the errors of the computation. The geometric mean is of course slightly smaller, but either mean is quite close enough for practical use. Replacing the mode in (17) by the arithmetic mean $(\overline{C})$, we have

$$X=\overline{DC} \tag{18}$$

so that the number of bacteria per cc. is calculated simply.

Representing the mode by the geometric mean (G_C), equation (17) becomes

$$X = G_D G_C \tag{19}$$

where G_D is the geometric mean of the dilution (D). Changing variables to the logarithm, this gives

$$x = \bar{d} + \bar{c} \tag{20}$$

as the relation between the arithmetic means of the logarithms, and

$$\left.\begin{aligned} x &\equiv \log X \\ \bar{d} &\equiv \log G_D \\ \bar{c} &\equiv \log G_C \end{aligned}\right\} \tag{21}$$

TABLE 2

CONSTANTS OF BACTERIAL FREQUENCY

Number of Bacteria per cc (s)	10	100
Arithmetic Mean Bacterial Count ($\overline{C}$)	9 995	100 001
Geometric Mean " " (G_C)	9 54	99 76
Standard Deviation (σ)	3 02	9 55
Variability ($100\frac{\sigma}{C}$)	30 per cent	9 6 per cent

The logarithms can be read conveniently from the two-place table. (Tab. 3).

TABLE 3

TWO-PLACE LOGARITHMS

	0	1	2	3	4	5	6	7	8	9
1	00	04	08	11	15	18	20	23	26	28
2	30	32	34	36	38	40	42	43	45	46
3	48	49	51	52	53	54	56	57	58	59
4	60	61	62	63	64	65	66	67	68	69
5	70	71	72	72	73	74	75	76	76	77
6	78	79	79	80	81	81	82	83	83	84
7	85	85	86	86	87	88	88	89	89	90
8	90	91	91	92	92	93	93	94	94	95
9	95	96	96	97	97	98	98	99	99	00

To illustrate the computation, an example is worked out. (Example 3.)

In any actual experiment the discrepancy between the two means is almost certainly due to experimental errors, and not to theoretical fluctuations of sampling. These errors are largest in the largest dilutions. The geometric mean is less affected by large errors in excess than is the arithmetic mean. On the other hand negative plates must be ignored, for a single one would make the geometric mean vanish. The question of what mean to use in this work, however, has little

theoretical importance. It is in space and time distributions that large variations and skewness may arise, and then the means differ significantly. In many such cases the geometric mean is more probable than the arithmetic mean, as will be shown in a later paper.

Example 3

EXPLANATORY FORM

Dilution D	Bacterial count C	DC	Deviation	d log D	c log C	$d+c$	Deviation
1 cc.	Too many to count						
10 cc.	(200)						
100 cc.	130	13,000	29,000	2	2 11	4 11	0.40
	190	19,000	23		2 28	4 28	.23
1000 cc.	82	82,000	40	3	1 91	4 91	40
	53	53,000	11		1 72	4 72	21
10,000 cc.	None						
Sums		167,000	103,000	5	8 02	18 02	1 24
Arith means		42,000 ±	13,000	2 5	2 01	4 51 ±	16

Arith mean of logs $\equiv x = 4\ 51$
Geometric mean $\equiv$ antilog $x = 32{,}000 \pm 14{,}000$

Number of bacteria per cc $\begin{cases} \text{Geom mean} \equiv G_X \equiv G_D\,G_C = \begin{cases} 32{,}000 \pm 14{,}000 \\ (3\ 2 \pm 1\ 4) \times 10^4 \end{cases} \\ \text{Arith mean} \equiv \overline{X} \equiv \overline{DC} = \begin{cases} 42{,}000 \pm 13{,}000 \\ (4\ 2 \pm 1\ 3) \times 10^4 \end{cases} \end{cases}$

ACTUAL ROUTINE FORM

DC	d	$d+c$	Dev
13,000	2	4 11	40
19		28	23
82	3	91	40
53		72	21
4 | 167		4 | 202	124

$\overline{DC} = 42{,}000 \pm 14{,}000$ $\quad x = 4\ 51 \pm 0\ 16$
$G_X = 32{,}000$

It should be emphasized that the logarithm itself furnishes a most convenient scale for the expression of results in bacteriology. Thus, instead of bothering to find the antilogarithm of x, this value itself can be used; $x=3.67$ means quite as much as $X=4.7\times10^3=4700$, when equally familiar, and it is much more convenient for very large numbers, as well as for graphical work. Moreover, the significant changes

are those in x, not X, for in bacterial phenomena the population must be taken into account. The logarithm of the number of bacteria, and not the number itself, should therefore be used for routine purposes.

SUMMARY

The chance (P_C) of finding C bacteria in α cc. of water containing X bacteria per cc. is

$$P_C = \frac{(\alpha X)^C}{C!} \exp.\ (-\alpha X)$$

This theorem is applied to the "per cent negative" (100 P_0) method of counting bacteria and to the method of counting positive plates.

It is shown that the variability in samples containing more than ten bacteria is small, so that differences between the arithmetic and geometric means cannot be due to fluctuations of sampling.

The extreme variability usually found in bacteriology is due to differences of locality and time In any case where the data vary very widely, a few very large values, representing perhaps less than one per cent of the results, may double the value of the arithmetic mean; their effect upon the geometric mean is but slight. This renders the arithmetic mean practically valueless

Bacteriological frequency distributions usually possess not only wide variability, but positive skewness. In such cases the geometric mean is more probable than the arithmetic mean, but the most important reason for preferring the geometric mean is its stability as an average.

PHYSICS —*Soft characteristic X-rays from arcs in gases and vapors.*[1]

F. L. MOHLER and PAUL D. FOOTE, Bureau of Standards.

If an electron current is maintained by a potential V between a hot cathode and anode in a vapor at low pressure, then as V is increased successive changes occur in the spectrum excited by electron impact. The highest frequency ν of each additional group of lines is related to the least potential required to excite the group by the quantum equation $Ve = h\nu$.

The authors have studied the stages in the discharge by measuring the photo-electric effect of the radiation on two other electrodes entirely shielded from ions produced in the arc. This photo-electric current plotted as a function of the exciting voltage shows nearly a linear relation with changes of slope at critical potentials. In this

[1] Received June 15, 1921.

manner potentials have been found which are determined by the limiting frequency of the softest X-ray series of a number of elements.

Table 1 gives the observed potentials, and the corresponding wave lengths for these X-rays. Carbon was studied in the compounds CO, CO_2, C_2H_4 and CCl_4. The latter compound also gave the chlorine points The nitrogen point was obtained from air and the other points from the various elements at temperatures giving suitable vapor pressures.

TABLE 1. Soft X-rays from Low-Voltage Arcs.

Element	Observed potentials in volts		λ in Å		Computed λ	Remarks
	a	b	a	b	L_a	
Sodium	35.	17.	353.	726.		
Magnesium	46.	34.	268.	363.	263	
Phosphorus	126.	99.	98.0	125.	92.2	
Sulphur	152.	121.	81.2	102.	77.2	
Chlorine	197.	156.	62.7	79.1	61.9	
Carbon	272.		45.4			K series limits
Nitrogen	375.		32.9			
Potassium	23	20.	536.	617.		M series limits

The limits L_a of the L series for light elements, computed from X-ray spectral data by the relation $L_a = K_a - K_\alpha$, are included in table 1. A plot of $\sqrt{1/\lambda}$ against atomic number shows that both the observed (column a) and computed points from magnesium to chlorine fall on the same straight line within the probable observational error. The points b for these elements lie on a nearly parallel line They indicate a new X-ray series of feeble intensity The value of L_a for sodium falls above the extrapolated straight line but is consistent with Millikan's recent observation of the L_α lines as $\lambda = 372$ and $376A$. The K limits found for carbon and nitrogen fall close to the extrapolated K_a line. The carbon point is in fair agreement with the value $\lambda = 42.6$ A found by Kurth[2] who observed the radiation from a solid carbon anode Theories of atomic structure indicate that the potassium points must be related to the M series.

The above preliminary results emphasize the value of this method of studying radiations in the region between the range of the vacuum spectroscope and the X-ray crystal spectrometer.

[2] Abstract in Phys Rev 17: 528 1921.

TERRESTRIAL MAGNETISM.—*The bearing of the earth's size upon changes in its magnetization.*[1] W. F. G. SWANN, University of Minnesota.

H. Lamb[2] has shown that if a system of currents is started in a sphere of the size of the earth, endowed with a conductivity equal to that of copper at normal temperature, a period of ten million years will elapse before the magnetic field becomes reduced to 1/e of its original value as a result of the decay of the currents The physical reason for this result lies in the very large effect of self induction in a body of the size of the Earth, as compared with the effect of resistance. The purpose of this note is to examine the bearing of this matter upon one or two questions relating to the Earth's magnetism. For the purpose in hand, it is unnecessary to give an exact mathematical analysis, and it will suffice to handle the problem in a way which does not claim more than a determination of the orders of magnitude of the elements involved. Such a simplified procedure serves, moreover, to keep the physical principles more prominently to the fore. In the first place, it may be of interest to verify Lamb's result by this method.

Decay of currents in a sphere.—If B is the average magnetic flux through a section of the sphere containing the equator of the axis of magnetic flux, the e. m. f. around the equator is $\pi a^2 dB/dt$, so that, considering an equatorial ring of unit cross section and specific resistance ρ we have:

$$\pi a^2 \frac{dB}{dt} + 2\pi a \rho i = 0 \qquad (1)$$

where i is the current density.

Now, at each instant, B is *of the order of magnitude* of the magnetic field at the equator of a sphere of radius a due to a current density which may be taken for convenience as proportional to the distance from the axis, and such as to have the value i on the equator. For this case, it may readily be shown[3] that the field at the equator is $4\pi i a/15$, so that, as regards order of magnitude, we may write

$$B = 0\ 25\pi i a \qquad (2)$$

for a sphere of unit permeability. Substituting in (1) we have, as

[1] Presented at the Washington meeting of the American Physical Society, April 29–30, 1921 Received May 25, 1921

[2] Quoted by A. Schuster in *A critical examination of the causes of terrestrial magnetism* Proc Phys. Soc Lond **24**: 124 1911–1912

[3] See for example, W F. G SWANN, *The Earth's magnetic field*, Phil. Mag (6) **24**: 97. 1912.

regards order of magnitude:

$$\frac{dB}{dt}+\frac{8\rho}{\pi a^2}B=0$$

leading to:

$$B=B_0\,e^{\frac{-8\rho}{\pi a^2}t}$$

Putting $\rho=1.6\times10^{-6}$ ohm/cm.^{3} $=1.6\times10^3$ e. m. u. for copper, and $a=6.5\times10^8$ cm., as corresponding to the radius of the earth, we readily find that $\pi a^2/8\rho=10^{14}$ seconds; so that, for $B/B_0=1/e$, we have $t=10^{14}$ seconds, that is, 3×10^6 years, which, in view of the approximations involved, is in sufficiently good agreement with Lamb's result.

Case of the destruction of a state of permanent magnetization.—It is usually maintained that the Earth cannot be a permanent magnet on account of the high temperature of its interior. It is interesting to observe, however, that if it had been a permanent magnet originally, the destruction of this magnetization would set up induced currents which would tend to perpetuate the field; and, as will appear, the net result would be that, for a body of the Earth's size, and with the conductivity of copper, about three million years would elapse before the field had sunk to a value 1/e of that prevailing before the magnetization was destroyed.

Suppose that B represents the average induction through a great circle of the order of magnitude of the radius of the sphere. Then equation (1) applies as before. Now if $\overline{B}$ is the induction due to the permanent magnetization, then for a sphere of unit permeability, which it will suffice to consider, i is of the order of magnitude obtained by replacing B by $B - B$ in equation (2), that is,

$$B-\overline{B}=0.25\pi ia$$

so that, using (1), we have, as regards order of magnitude,

$$\pi a^2\frac{dB}{dt}+8\rho\,(B-\overline{B})=0 \qquad (3)$$

Suppose now that the permanent magnetization $\overline{B}$ decreases according to the law.

$$\overline{B}=\overline{B}_0\,e^{-\alpha t}$$

Then, from (3),

$$\frac{dB}{dt}+\frac{8\rho}{\pi a^2}B=\frac{8\rho}{\pi a^2}\overline{B}_0e^{-\alpha t} \qquad (4)$$

The solution of this equation, subject to $B=\overline{B}_0$ when $t=0$, is:

$$B = \frac{\overline{B}_0}{1-\frac{8\rho}{\pi a^2 \alpha}}\, e^{\frac{-8\rho}{\pi a^2}t} - \frac{\frac{8\rho}{\pi a^2 \alpha}\overline{B}_0}{1-\frac{8\rho}{\pi a^2 \alpha}} e^{-\alpha t}$$

To fix our ideas, suppose that the permanent magnetization is practically destroyed in a time short compared with $\pi a^2/8\rho$, which, for copper, and for a equal to the radius of the Earth, amounts to 10^{14} seconds. Then $8\rho/\pi a^2\alpha$ is a small quantity, and we have approximately:

$$B = \overline{B}_0\, e^{-\frac{8\rho t}{\pi a^2}}$$

so that, even though the permanent magnetization is destroyed rapidly, the order of magnitude of B will still be B_0/e after a lapse of 10^{14} seconds, or three million years

APPLICATION TO THE SECULAR VARIATION

Such evidence as exists with regard to the secular variation appears to indicate that the magnetic poles describe closed curves about the geographic axis with a period of the order of 500 years The curve is possibly accompanied by smaller loops, which need not concern us here, however.

Suppose that, as a first approximation, we divide the Earth's magnetization into two uniform magnetizations, one parallel to and one perpendicular to the geographic axis, and regard the latter as rotating, with regard to the earth itself, once in 500 years We do not know the mechanism of the process; but, it is interesting to inquire as to what would follow by considering it merely as a rotation of a state of permanent magnetization in the above manner We shall find that the induced currents play a very important part, both as regards their power to almost cancel the effect of the rotating permanent magnetization, and also as regards their influence in producing a lag of the resultant magnetization behind the permanent magnetization.

If D_0 refers to the permanent component of magnetization perpendicular to the geographic axis, then, on considering the case of a meridian circle, we shall have an equation similar to (4), but with $B_0e^{-\alpha t}$ replaced by $D_0 \cos 2\pi t/T$, where $2\pi t/T$ represents the angle between the direction of D_0 and the perpendicular to the plane of the meridian circle in question. As regards order of magnitude we thus have:

$$\frac{dB}{dt} + \frac{8\rho}{\pi a^2} B = \frac{8\rho}{\pi a^2} D_0 \cos\frac{2\pi t}{T}$$

The complementary function may be neglected after a sufficiently long time, and we shall be left with the particular solution:

$$B = \frac{D_0}{\left(1+\frac{\pi^4 a^4}{16T^2\rho^2}\right)^{1/2}} \cos\left(\frac{2\pi}{T}t - \Theta\right)$$

$$\text{where } \tan\Theta = \frac{\pi^2 a^2}{4\rho T}$$

There is thus a lag, and a reduction of amplitude in the ratio unity to $(1+\pi^4a^4/16T^2\rho^2)^{1/2}$.

If T is of the order of 500 years, and ρ corresponds to copper, this ratio amounts to 0.27×10^{-4}. Thus, if the resulting apparent magnetization perpendicular to the geographic axis is to be at all comparable with the permanent magnetization (or its equivalent[4]) perpendicular to that axis, the internal conductivity of the Earth must be smaller than that of copper at least in the ratio $0\ 3\times10^{-4}$ to unity. Of course, there is nothing remarkable in this since presumably nobody would wish to consider the conductivity of the Earth's interior as comparable with that of copper, but it is nevertheless of interest to observe that the period of the secular variation has something to say as regards an upper limit to the conductivity in question

When one pictures the flow of currents left to themselves in a sphere, he is likely, at first sight, to regard resistance as the main influence controlling them. We see, however, that in the case of a large sphere, such currents are more analogous in their behavior to highly frictionless gyroscopes, and the problems of precession, etc., associated with gyroscopic motions naturally invite attention.

The pertinence of the above to problems concerning magnetic fields in sun-spots is obvious

PETROLOGY.—*Preliminary note on monticellite alnoite from Isle Cadieux, Quebec.*[1] N L. BOWEN, Geophysical Laboratory, Carnegie Institution of Washington.

The occurrence of alnoite in the vicinity of Montreal, Canada, has been known for some years The first discovery was made by Adams,[2] and a paper by Harvie[3] describes a number of separate intrusives of this nature. During the past summer Doctor Harvie called to my

[4] We are not limited to the case of a rotating permanent magnetization as the active agency Thus we might consider a system of e m f 's of unspecified origin, whose effects were to generate currents which would act as the equivalent of the permanent magnetization cited

[1] Received June 11, 1921

[2] F D ADAMS Amer Journ. Sci (3) 43: 269–279 1892

[3] ROBERT HARVIE *On the origin and relations of the Palaeozoic breccia of the vicinity of Montreal* Trans Roy Soc Canada (3) 3: Sect 4, 249–299. 1909.

attention the fact that some new occurrences had been found in the course of a road-materials survey of the area which involved, in a petrographic way, merely the identification of the rock as alnoite.[4] An examination of one of these occurrences, that at Isle Cadieux, proved it to be of particular interest, and I am greatly indebted to Dr. Harvie and to the Director of the Geological Survey of Canada for the opportunity of making a more detailed study.

The rock is on the whole particularly fresh for a rock of this kind and the paragenesis of its minerals unusually clear. A fuller description will be given in a paper now in course of preparation which embodies also experimental studies designed to throw some light on the mineral relations In the meantime it was thought desirable to publish a note on the petrography of the rock mass

The greater part of the rock is a fine-grained dark gray mass in which the individual minerals are not distinguishable in the hand specimen except in the case of large poikilitic biotites that are its principle constituent.

Under the microscope the rock is seen to consist of biotite, olivine, augite, melilite, perovskite, apatite, titaniferous magnetite, and alteration products, largely carbonates. It is therefore a typical alnoite but differs from all alnoites as hitherto described in that it contains two olivines, namely, ordinary chrysolite and also monticellite, the latter usually in amounts considerably in excess of the amount of chrysolite.

Monticellite, biotite, and melilite constitute groundmass minerals and often poikilitically include augite and chrysolite Plainly a great deal of resorption of augite and chrysolite has occurred, their places being taken by biotite, monticellite and melilite. There is therefore a marked difference between the chrysolite and monticellite in the manner of their occurrence Not infrequently monticellite forms a reaction rim about chrysolite with the two olivines in optical continuity In such cases the great difference in birefringence is particularly clear on account of their uniform orientation. In addition to the different mode of occurrence and the greatly inferior birefringence of the monticellite it is further contrasted with the chrysolite in being plainly optically negative, whereas the chrysolite is just upon the border between the positive and negative members of the forsterite-fayalite series and its sign is therefore doubtful.

[4] Geol Survey Canada, Summary Rept. 1916: 198–206.

Only those distinctive features of the two olivines that are readily seen in thin section are given here. Chemical evidence and more detailed optical measurements are available, but await the final paper in which the characters of the other minerals and variations within the mass will be discussed.

An analysis of one of the freshest specimens has kindly been made by Dr. H. S. Washington and is given in table 1.

TABLE 1.

CHEMICAL ANALYSIS OF MONTICELLITE ALNOITE

Isle Cadieux, Quebec H S Washington analyst

SiO_2	33 26	H_2O-	0 09
Al_2O_3	5 90	CO_2	1 10
Fe_2O_3	5 30	TiO_2	2 15
FeO	6 54	P_2O_5	0 76
MgO	26 41	MnO	0 15
CaO	14 47	Cr_2O_3	0 05
Na_2O	1 23	BaO	0 08
K_2O	0 82	SO_3	0 22
H_2O+	1 91		
		Sum	100 44

This specimen was chosen primarily for its freshness and, while not an uncommon facies, is not altogether representative of the usual type. It contains more melilite than biotite and somewhat more chrysolite than monticellite, whereas these conditions are reversed in the average rock of the mass. If the amounts of CO_2 and H_2O be taken as criteria, this is the least altered alnoite that has yet been analyzed

Monticellite as an igneous rock mineral.—Monticellite, the lime magnesia olivine, has hitherto been supposed to occur only in contact metamorphic rocks That it can crystallize directly from melts of the appropriate composition has been shown by Ferguson and Merwin.[5] That it has not been found in igneous rocks before is in part due to the fact that natural magmas have usually not been of appropriate composition and it was not present, but it may also be due to the fact that it has, at times, escaped detection even though present. I have examined a series of slides made from specimens from the original Alno locality. Only one of these is of alnoite (labeled fine-grained alnoite Aldersnäset, Alnö[6]) and in this I find that many of the chrysolite grains are surrounded by rims of monticellite, always in optical

[5] Amer Journ Sci (4) 48: 81–123 1919

[6] The specimens are the property of Dr. WASHINGTON and were collected by Dr HÖGBOM. A duplicate of this collection is in the U. S Geological Survey Petrographic Reference Collection, where this rock is No. 1044.

continuity. The resorption relation between the two minerals is plain and the monticellite is here again a groundmass mineral, while the chrysolite occurs as resorbed early crystals. It seems not improbable that other related rocks may contain monticellite and they should be examined carefully with this in mind. It should be noted that monticellite is readily altered, apparently even more readily than melilite, and its presence is to be expected only in the freshest material.

Summary.—In this paper monticellite alnoite from Isle Cadieux, Quebec, is described. The rock shows the two olivines chrysolite and monticellite, the latter usually in greater amount. The chrysolite, together with augite, occurs in early formed crystals, while the monticellite, as well as melilite and biotite, occur as groundmass minerals that have attacked and resorbed the chrysolite and augite. Monticellite often forms reaction rims around chrysolite that are in optical continuity with it

Monticellite alnoite is a newly recognized but not a new rock type, for some of the alnoite of the original type locality is found to hold monticellite showing the same relationships.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

PHYSICS.—*Polarized light in the study of ores and metals.* FRED. E. WRIGHT. Proc. Amer. Phil. Soc. **58**: 401–447. 1919

In this paper the attempt has been made to present in connected form the electromagnetic theory of the reflection of light from absorbing media, and especially that part of the theory which treats of the reflection phenomena resulting from vertically incident light-waves under the conditions usually encountered in the use of the reflecting or metallographic microscope. Normally incident white light contains, after reflection by an anisotropic substance, a certain amount of plane-polarized light, and this amount increases with the strength of the birefringence and the biabsorption in the crystal plate. The presence of plane-polarized light in natural light can be detected by several different methods, such as are used in determinations of sky polarization. For this purpose Koenigsberger adopted the Savart method with rotating glass compensator. A second and new method is proposed which employs either a single calcite cleavage plate with proper aperture or a small portable Koenig-Martens photometer. This method is more sensitive than the first. Methods of this kind, which are based on differences in intensity of the reflected components of vertically incident light, are fifty or more times less sensitive in the detection of anisotropism than methods based on the phenomena produced by plane-polarized transmitted light-waves.

In case vertically incident, plane-polarized light is used, the difference in amplitude of the reflected components causes a rotation of a plane of polarization, and this can be detected and measured by any one of a number of devices

in common use by petrologists, such as the sensitive-tint quartz plate, the Biot-Soleil sensitive-tint biplate, the Bertrand eyepiece, and the biquartz-wedge plate. Of these, the last is the most sensitive, because in it the sensibility is variable and can be adjusted to meet the conditions of illumination.

In opaque substances the precision attainable by these methods is, in general, small, and the phenomena which can be observed are relatively few and restricted in scope. As a result, one can not expect from the application of polarized light to such substances the harvest of optical data which has been gathered from transparent crystals. F. E. W.

PHYSICS.—*The measurement of the intensity of transmitted and reflected light by polarization photometers.* FRED E. WRIGHT. Journ. Opt. Soc. Amer. **2**: 65–75. 1919. (Geophysical Lab. Papers on Optical Glass, No. 22*a*.)

In this article a brief statement is given of the methods used by the writer during the war period for the measurement of the light transmission of optical glasses and of optical instruments. Several new attachments and improvements on the Koenig-Martens photometer are described; also the method for their use in the practical measurement of the amount of light transmitted and reflected by optical glasses, and of the light transmission of optical instruments. F. E. W.

PHYSICS.—*Polarization photometer prisms* FRED E. WRIGHT. Journ. Opt. Soc. Amer. **2**: 93–96. 1919. (Geophysical Lab. Papers on Optical Glass, No. 22*b*.)

In this paper is considered the quantitative effect of external and internal reflections on the intensity of light-waves transmitted by the calcite rhomb and the Wollaston prism, when these are used in photometric work. This discussion is necessary to an adequate understanding of polarization photometers and the factors underlying their use. F. E. W.

GEOLOGY.—*The future of Alaska mining.* ALFRED H. BROOKS. U. S. Geol. Survey Bull. 714-A. Pp. 56, pls. 3, fig 1.

Although many local factors affect the future of Alaska mining, the most important consists of the mineral reserves. An estimate of Alaska's mineral reserves would be difficult enough, even with complete geologic maps. Only twenty per cent of the Territory has been covered by even reconnaissance geologic surveys, and less than one per cent by detailed surveys. The information at hand does not permit of even approximate quantitative estimates of reserves. It indicates, however, the areal distribution of the mineral deposits and a study of their geologic occurrence gives a basis for forecasting their availability to the miner.

The wide distribution of placer gold in Alaska and the known occurrence of many gold-bearing quartz veins shows the large areal extent of the auriferous mineralization. Furthermore, the wide distribution of intrusive granites, with which the occurrence of gold is genetically related, augurs well for future discoveries. The Alaska placers have during 40 years of mining produced $218,000,000 worth of gold. A careful consideration of all the facts available indicates that the placer gold reserves have a value of at least $360,000-000.

The Alaska copper deposits are widespread and are found in a number of different modes of occurrence and geologic relations. It is important to note that the Alaska copper deposits thus far developed are primary. The practical deduction from these facts is that no greater variation in the mineral

composition and copper content of the ores is to be expected at depths to be reached by future mining than has already been noted a few feet below the surface. Alaska has produced a total of 272,500 tons of copper.

The Alaska coal reserves include enormous quantities of lignite, considerable low-grade bituminous coal, and much smaller quantities of high-grade bituminous coal and anthracite. There are many other potential mineral deposits in Alaska in addition to those listed above. Of these, the petroleum fields give the most promise for immediate development. Between 1880 and 1919 Alaska produced mineral wealth to a total value of $438,160,000. A. H. B.

ZOOLOGY.—*The Echinoderms of the Canadian Arctic Expedition, 1913–18.* AUSTIN H. CLARK. Rep. Canadian Arctic Exped. 1913-18, Vol. **8**, Part C, Echinoderms. Pp. 11 (1C-11C).

The echinoderms, 2024 specimens representing 20 species, secured by the Canadian Arctic Expedition, are herein described and the relationships of the Canadian Arctic fauna are discussed. A. H. C.

ZOOLOGY.—*Additional data for the Report on Echinoderms of the Canadian Arctic Expedition, based upon specimens from the "Neptune" and other Eastern Arctic Expeditions.* A. H. CLARK. Rep Canadian Arctic Exped. 1913–18, Vol. **8**, Part C, Echinoderms. Pp. 3 (11C–13C).

Herein is recorded additional arctic material in the collections of the Victoria Memorial Museum at Ottawa. A. H. C.

ZOOLOGY.—*Sea-Lilies and Feather-Stars.* AUSTIN H. CLARK. Smithsonian Misc. Coll. **72**, No. 7, 1–43, pls. 1–16. 1921.

This is a semi-popular summary of the present-day knowledge in regard to living crinoids; it includes a considerable amount of hitherto unpublished information, especially concerning the color of these animals, the extraordinary similarity between crinoids and plants, and the conditions of parasitism under which crinoids live. A. H. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

846TH MEETING

The 846TH meeting was held in the assembly hall of the Cosmos Club on February 12, 1921. The meeting was called to order by President FARIS with 66 persons present. The following program was given.

C. LEROY MEISINGER: *The meteorological factor in aeronautics* (illustrated).

For various reasons the public confidence, the essential factor in business success, has not been acquired in commercial aeronautics, and it behooves enterprises engaged in promoting civil aviation to take advantage of every agency which will help in this direction. Meteorology is such an agency and its application to aeronautics is two-fold: climatological, dealing with average conditions of the elements; and current, dealing with conditions prevailing at the time of flight.

The functions of the Weather Bureau in relation to aeronautics are (1) to collect and disseminate observational data, (2) to forecast for specified regions; and (3) to conduct researches The limitations of the work of the governmental agency are expected to evolve the aeronautical meteorologist, privately retained by commercial concerns. His duties will consist

in (1) the interpretation and detailing of information for specific craft in flight; (2) the dispatching of craft; (3) the furnishing of information to other departments of the concern; and (4) the instruction of pilots.

Governmental activities must be expanded along lines of the collection of aerological information. With this assistance, the general flying weather forecasts will probably keep pace with the development of the demand. The making of upper air pressure maps is the type of research problem of great assistance in forecasting. The status of this problem was discussed. The work of the commercial meteorologist can be surmised by reference to charts of upper air conditions along flying routes. This paper has appeared in full in the *Monthly Weather Review.*

L. H. ADAMS and E. D. WILLIAMSON: *The density of strained glass* (illustrated, presented by Mr. Adams.)

The stresses existing in "strained" glass are such that in the interior portion of the glass the density is less than that of unstrained (annealed) glass, while in the outer portion it is greater. It can be demonstrated, however, that in any strained piece of glass these two effects exactly neutralize each other, so that the total volume of the piece is unaffected by strain. In order to reconcile this conclusion with the experimental results which always show a smaller density for strained glass when compared with unstrained glass, it is necessary to assume that the apparent diminution of density is due to the formation of bubbles in the interior, where a hydrostatic negative pressure exists. This agrees with the conclusion reached many years ago by Barus that the low density of Prince Rupert's drops is a consequence of the presence of *vacuum* bubbles.

G. T. RUDE: *The tidal work of the Coast and Geodetic Survey* (illustrated).

Tidal work of the Coast and Geodetic Survey had its origin in the necessity for reducing soundings, in hydrographic surveys, for the fall and rise of the tides. The needs of the engineer and mariner have necessitated the extension of the work until now it covers the following fields Prediction of tides and preparation of annual tide tables, determination of datum planes, development of instruments for observing and predicting tides; study of mean sea level and its relation to crustal movements, and the study of tidal phenomena in general.

The issue of tide tables for the use of the mariner began in 1853 with a condensed table for eight stations for the United States. These tables have increased in size and scope so that now they appear annually, in advance, as a volume of about five hundred pages covering the entire maritime world, with full predictions for each day of the year at eighty-one principal ports and tidal differences for more than thirty-five hundred subsidiary ports.

Prior to 1882 the tides were predicted by means of empirical tables and graphs. Beginning with that year the predictions were made on a machine designed by Mr. William Ferrel of the Survey. This machine was essentially a maxima and minima machine and in 1910 it was replaced by a new tide-predicting machine designed and constructed in the office of the Survey. On this new machine the height of the tide at any time between high water and low water is indicated, and the time and height of the tide are indicated on the face of the machine, from which they can be recorded directly on forms for the printer. The setting of the machine and the prediction of tides for a full year at any station require about ten hours.

It is, of course, out of the question to predict the tides for all ports. To

secure the state of the tide at places where no predictions are made, it is customary to refer such places to some port for which predictions are made. The referring of a subsidiary port to the proper standard port has led to a study of the different types of tides, the principal ones of which are the semi-daily, the daily and the mixed. In the semi-daily tide we have two high and two low waters every day, with morning and afternoon tides very much alike. In the daily tide we have only one high and one low water a day. In the mixed type of tide, caused by a combination of the two preceding types, we have two low and two high waters a day, but with differences in duration and height of morning and afternoon tides.

In all types of tides we find a variation with the moon's declination. When the declination is small, the forces giving rise to the daily wave are small, and at such times we may have semi-daily tides even at places where the daily is the predominating type. When the declination of the moon is large the daily forces are at a maximum, and we will have even in the semi-daily tide a difference between the morning and afternoon tides.

Formerly surveyors and engineers made use of arbitrary or local datum planes. To eliminate the confusion resulting from this practice, which frequently made it impossible to correlate the results of recent with the previous surveys, the Coast and Geodetic Survey has been establishing datum planes, based on tidal definition, for the coasts of the United States. The great advantage of the tidal datum plane lies, not only in its simplicity of definition, but also in the certainty with which it may be reestablished at any future time.

For practical purposes a tidal plane determined from a series of observations covering a period of a month may be considered as well determined However, such planes determined at different times may differ considerably, and for the accurate determination, it is necessary to have long-continued observations at selected representative points. At these principal stations the Survey maintains self-registering tide gauges, which automatically record the height of the tide. Such observations covering a number of years bring out changes in mean sea level and furnish the data for a quantitative determination of relative changes in elevation of land and water.

The space allotted permits the covering of only the practical phases of the tidal work of the Survey as they relate to the needs of the engineer and mariner. The theoretical phases, however, as they relate to the development of the theory of tides, have not been neglected. The tidal papers of William Ferrel and R. A. Harris were results of the Survey's tidal studies along these lines

The first paper was discussed by Messrs SOSMAN, LLOYD and HUMPHREYS.

D. L HAZARD, *Corresponding Secretary.*

847TH MEETING

The 847th meeting was held in the assembly hall of the Cosmos Club on February 26, 1921. The meeting was called to order by President FARIS with 41 persons present. The program was as follows

F. HASTINGS SMYTH and HOWARD S. ROBERTS *The system cupric oxide cuprous oxide, oxygen,* (illustrated, presented by Mr. Smyth).

This system has been studied by several investigators, notably by FOOTE and SMITH, and L. WÖHLER has argued rather convincingly that a continuous series of solid solutions exists between the two copper oxides, and that at

any given temperature the oxygen equilibrium pressure is dependent on the composition of the solid phase.

The authors' results show that solid solutions are absent, and that the following reactions may take place in the system:

(1) $4CuO(s) \rightleftharpoons 2Cu_2O(s) + O_2(g) - \Delta H_1$

(2) $4CuO(s) \rightleftharpoons 2Cu_2O(l \text{ solution in } CuO) + O_2(g) - \Delta H_2$

(3) $4CuO(l \text{ solution in } Cu_2O) \rightleftharpoons 2Cu_2O\ (s) + O_2(g) - \Delta H_3$ where ΔH_1, ΔH_2, and ΔH_3 are the heat quantities absorbed in each reaction.

At 1080.2°C and an oxygen equilibrium pressure of 402.3 mm. Hg, a eutectic containing 72.7 mol per cent Cu_2O and 27.3 mol per cent CuO fuses. Below this point, therefore, Reaction (1) takes place; above this point either Reaction (2) or (3) takes place, dependent upon the quantity of oxygen originally present in the solid and liquid phases. The pressure-temperature curves for these reactions have been traced experimentally up to temperatures of 1085.0°, a metastable point, for Reaction (1), to 1232.5° for Reaction (2); to 1231.3° for Reaction (3).

Theoretically the course of these curves, which intersect at the quadruple (eutectic) point of the system can be followed by means of the general equation

$$dp/dt = \Delta n/\Delta v$$

which, under conditions of constant temperature and pressure, becomes

$$dp/dt = 1/T . \Delta H/\Delta V$$

ΔH_1 remains substantially constant over the temperature range studied. ΔH_2 can be considered as the algebraic sum of ΔH_1 and of additional heat absorbed by fusion of Cu_2O and of additional CuO to form the liquid solution. ΔH_2 is therefore greater than ΔH_1 and the value of dp/dt above the eutectic point is always greater than that of the extrapolation of curve for Reaction (1). Likewise ΔH_3 is always less than ΔH_1 and the slope of the curve for Reaction (3) is always less than that of the extrapolation of the curve for Reaction (1).

The curve for Reaction (2) is tangent to the curve for the condensed system $CuO(s)$, $CuO(l)$ at the melting point of pure CuO, that for Reaction (3) is tangent to the curve for the system $Cu_2O(s)$, $Cu_2O(l)$ at the melting point of Cu_2O. The melting point of pure CuO has not been reached.

The melting-point diagram for mixtures of the two copper oxides, under equilibrium pressures of oxygen, has been established throughout the range 94.4 mol per cent Cu_2O to 45.9 mol per cent Cu_2O.

Lower equilibrium pressures were determined in a fused silica tube reaction chamber with a mercury manometer attached. Higher pressures were determined with a furnace enclosed in a brass bomb, and with a calibrated Bourdon gage. Temperatures were measured by means of a platinum-platinrhodium thermoelement. Purified electrolytic oxygen was used and copper oxides were prepared from previously analyzed chemically pure metallic copper

The paper was discussed by W. P WHITE.

F. WENNER, J. S. MARTIN, and NYNA L. FORMAN *The electrical resistance of the human body.* (Illustrated, presented by Mr. Wenner).

Measurements of the electrical resistance of the human body have given results differing among themselves so radically that one seeking information on the subject is led to question either the reliability of the work or the significance of the values given.

The difficulties encountered have had their origin mainly in those portions

of the skin through which the test current entered and left the body. The skin not only has a high and uncertain resistance, but in it there are capacity, polarization, and possibly other effects which not only make the measurements difficult but largely destroy their significance It seemed, therefore, that it might be of interest to measure the resistance of some parts of the body not including those portions of the skin through which the test current enters and leaves. To thus limit the parts whose resistance is to be measured, use is made of four connections to the body. Two of these serve to lead the test current to and from the body and two serve to bring the potential difference developed in a particular part of the body, as a result of the test current, to a place where it can be measured

Ordinarily we understand the resistance of a conductor to be the ratio of the drop in potential in it to the current flowing. However, when a conductor has four terminals to which electrical connections can be made, the resistance is understood to be the ratio of the drop in potential between the potential terminals to the current entering and leaving through the current terminals. In either case the potential considered should be only that caused by the current and not that which may arise in some other way.

In some of the measurements the left hand and the left foot were used as a pair of current terminals, and the right hand and right foot as a pair of potential terminals. Electrical connections to the hands and feet were made by placing them in vessels containing a solution of common salt in water These vessels are either lined with metal, or contain a piece of metal having a fairly large surface. Insulated wires are attached to the pieces of metal or to the metal lining and serve as leads for connecting the body into the circuits used in making the measurements. The resistance of the four-terminal conductor formed in this way is substantially the resistance of the trunk of the body with all the connecting resistances and practically all disturbing influences eliminated.

In most cases the resistance has been found to be between 20 and 30 ohms.

The paper was discussed by Messrs SILSBEE, WHITE, C. A. BRIGGS, and others.

H. H. KIMBALL, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The following officers were elected at the annual meeting of the Maryland-Virginia-District of Columbia Section of the Mathematical Association of America, held at the drafting hall of the Capitol on May 7. *President*, OSCAR S. ADAMS of the Coast and Geodetic Survey, *Secretary-Treasurer*, G. R. CLEMENTS of the U. S. Naval Academy, Annapolis, *Member Executive Committee*, F. D. MURNAGHAN of Johns Hopkins University, Baltimore.

The National Geographic Society is sending an expedition this summer to explore and study the Pueblo Bonito and Pueblo del Arroyo ruins in the Chaco Canyon of northwestern New Mexico. The expedition will be led by Mr. NEIL M. JUDD of the U. S. National Museum.

Recent accessions in the Division of Plants of the National Museum include 400 specimens from China and New Caledonia, received as an exchange from Mr. G. BONATI of Lure, France; 250 specimens of Chinese plants, collected by SIMEON TEN, purchased from the Arnold Arboretum in Boston; and 713 specimens from Quebec, received as an exchange from the College de Longueuil.

The semi-annual meeting of the Advisory Committee on Non-Ferrous Alloys was held at the Bureau of Standards on April 20 and was attended by members of the various technical societies representing the non-ferrous industries and also by representatives from the technical services of the War and Navy Departments The subjects discussed included specifications for hard-drawn brass wire for airplane bomb release, rotating bands for projectiles, various aircraft problems related to aluminum alloys, questions concerning the composition of bearing metals, corrosion and etching of metals, and the part played by gases in metals.

The new Low Temperature Laboratory of the Bureau of Mines was dedicated by Madame CURIE at 10 a m. on Saturday, May 21.

The National Screw Thread Commission met at the Bureau of Standards on Monday, April 18, and considered the Progress Report recently issued and outlined a program for continuing the work of the Commission.

Messrs L. H. ADAMS and E. D WILLIAMSON of the Geophysical Laboratory, Carnegie Institution of Washington, have received the Longstreth Medal from the Franklin Institute of Philadelphia in recognition of their work on the annealing of glass.

Dr. C. F. BROOKS, meteorologist at the Weather Bureau and editor of the *Monthly Weather Review*, has resigned, effective June 30, to accept the associate professorship of meteorology and climatology at Clark University, Worcester, Massachusetts

Mr F. C. BROWN of the Bureau of Standards returned in May from a two months' trip to the scientific institutions of England, France, and Germany.

A meeting in honor of Madame CURIE was held at the National Museum on Friday evening, May 20 Dr. ROBERT A MILLIKAN of the University of Chicago lectured on *Radium*

Dr FREDERICK B. POWER, of the Bureau of Chemistry, was presented with a gold medal by Mr HENRY S WELLCOME, founder of the Wellcome Chemical Research Laboratories of London, "in commemoration of his eighteen and one-half years of service as Director of the Laboratories and in recognition of his many valuable researches in the field of organic chemistry." The presentation took place at the Cosmos Club on May 9

Dr. EDWARD BENNETT ROSA, chief physicist of the Bureau of Standards, died suddenly in his office at the Bureau on May 17, 1921, in his sixtieth year. Dr. Rosa was born at Rogersville, New York, October 4, 1861 After graduation at Wesleyan and Johns Hopkins Universities, he became instructor at the University of Wisconsin, and then professor of physics at Wesleyan. He was appointed chief physicist of the Bureau in 1901. At Wesleyan he developed the physical side of the respiration calorimeter with W O ATWATER. At the Bureau his attention was directed to the determination of the fundamental electrical units and constants, including the ampere and the electromagnetic-electrostatic ratio, and also to numerous engineering problems, particularly during the War. During the past three years he had devoted much thought and labor to the problem of the Federal Government's scientific personnel and its reclassification by Congress, and his papers on this subject, first published in this JOURNAL[1] and widely reprinted, have focussed much public attention upon this important matter. He was a member of the ACADEMY and the Philosophical Society of Washington, as well as of many national scientific and technical organizations.

[1] This JOURNAL 10: 341–382, 533–558 1920

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CHEMISTRY.—*The evolution of matter.*[1] FRANK WIGGLESWORTH CLARKE, U. S. Geological Survey.

During the greater part of the nineteenth century many philosophical chemists held a vague belief that the so-called chemical elements were not distinct entities, but manifestations of one primal form of matter, the *protyle*, as it was sometimes termed. Other chemists, more conservative, looked askance at all such speculations, and held fast to what they regarded as established facts. To them an element was something distinct from all other kinds of matter, a substance which could neither be decomposed nor transmuted into anything else One fact, however, they ignored, namely, that the elements were intimately connected by many relations, which are best shown in the periodic law of Mendeléeff, who actually predicted the existence of unknown elements which were afterwards discovered. This is ancient history, with which all chemists are now familiar. It became evident to most chemists that the elements must have had some community of origin, for otherwise their relations to one another are unintelligible

In 1873 I ventured to publish the suggestion,[2] based on spectroscopic evidence and assuming the nebular hypothesis to be true, that the evolution of planets from nebulae had been accompanied by an evolution of the chemical elements The nebulae are chemically simple, the hotter stars more complex, the cooler stars and the Sun still more so, and the solid Earth the most complicated of all. This was promptly denounced as heresy; but nearly a year later Lockyer[3] put forth an analogous suggestion, based upon the same sort of evidence, but starting from the other end. That is, he assumed that in the hotter stars some elements were dissociated, and his suggestion was received with a good deal of favor. The heresy was beginning to be orthodox. In course of time the discovery of radioactivity by Becquerel and of radium by Madame Curie established the fact that

[1] Published with the permission of the Director, U S Geological Survey. Received June 16, 1921.

[2] F. W. CLARKE, *Evolution and the spectroscope*. Pop. Sci Mon. January, 1873.

[3] N. LOCKYER, Proc Roy. Soc 21: 513. (Paper dated Nov 20, 1873).

some, at least, of the elements were really unstable. The evolution of helium from radium, discovered by Ramsay and Soddy, made the evidence for this instability complete; a derivation of one element from another had actually been observed.

These discoveries opened a new field of research; and it was soon found that the elements at the top of the atomic weight scale, namely, uranium and thorium, are spontaneously but slowly decaying, yielding more than thirty new substances which differ widely in point of stability. To each one a half-life period is assigned, measured in some cases by thousands of years, in others by fractions of a second. Among these are two new varieties of lead; one derived from uranium, the other from thorium, which chemically are not distinguishable from ordinary or normal lead except by differences in their atomic weights and their specific gravities. The lead from thorium has an atomic weight about a unit higher, and that from uranium about a unit lower, than the atomic weight of normal lead. To this class of facts I shall refer later, as evidence in support of my arguments. That chemical elements can decay is the essential fact to be remembered.

That the chemical elements were formed by a process of evolution from the simplest forms of matter can hardly be doubted now, but the process is not yet ended They were developed at high temperatures; but when a certain stage was reached in the cooling mass they began to combine with one another to form the new class of substances which are known as compounds. These, obviously, represent an advanced degree of complexity, with corresponding instability; and with varying conditions both combinations and decompositions, such as are reproducible by human agencies, constantly occur. By this extension of the evolutionary process the solid Earth was built up, but in principle the process is the same throughout. From the formation of the first elements to the chemical changes now taking place upon the Earth there is no real interruption. One line of progress has been followed until a maximum of natural complexity and instability is reached in the organic compounds which form the basis of all physical life, whether vegetable or animal. The same fundamental matter, governed by the same fundamental laws, appears from beginning to end of the evolutionary process.

Between the formation of an element and the formation of a compound there is, however, an apparent difference. The first stage of the process was one which required a vast period of time, the second stage is marked by rapidity. The series of elements was slowly

formed, and their rate of decay, as shown between uranium and lead, is also relatively slow. The formation and decomposition of compounds, on the other hand, is rapid; and in some cases their rate is measurable. The distinction is not absolutely definite, for some of the short-lived products of radioactive decay seem to be exceptions to the rule, which in general may be stated as follows: The process of evolution is characterized by progressive acceleration, being slow at first, and becoming gradually more and more rapid. Its rate of acceleration may not be uniform but the general drift is clear. It follows the line from the simplest substances to the most complex. In all vital processes the ease and rapidity with which compounds are formed and developed is evident, and some of these substances are extremely complicated.

In any attempt to discuss the evolution of the chemical elements we have for guidance some facts and many analogies. That the most complex elements are unstable we have already seen, and it is suspected that all the others follow the same rule. Potassium and rubidium are feebly radioactive, which is an evidence of instability, and other confirmatory evidence will be cited later. Stability, however, is a relative term, and a substance which is stable under certain conditions becomes unstable under others. The prime factors which determine external stability are temperature, pressure, and chemical environment. For example, some compounds which are stable in anhydrous surroundings are decomposed in presence of water Calcium carbonate, under ordinary conditions, is divided at high temperatures into carbon dioxide and lime, but heated in a steel bomb it not only remains undecomposed, but it may even be melted, to form upon cooling a crystalline marble. Examples like these might be multiplied indefinitely. As a rule stability diminishes with increasing temperature, but is favored by increased pressure. We may also assume that the more symmetrical an atom or compound is, the more stable it is likely to be. We are dealing now with compounds, but to the evolution of the elements the same general rules must apply.

Now, returning to our main problem, was the evolution of the elements a regular progression, such as might be represented by a smooth curve or a straight line; or was it irregular and quite independent of their order in the scale of atomic weights? To answer this question we must try to imagine what happened in the development of the larger masses, the nebulae and the stars. On this subject there is a plausible hypothesis which has been favored by many astronomers;

namely that the nebula at first was relatively cool, that the temperature gradually rose to that of the hottest stars, and then regularly declined to the end of the series, the solid planet. A gaseous mass, contracting under the influence of gravitation, became warmer; at its center where the pressure was greatest, the increasing condensation generated still higher degrees of temperature, until a luminous nucleus was formed As condensation went on with increasing intensities of pressure, the temperature continued to rise until the heat generated by compression was less than that lost by radiation into space, when cooling began Although this hypothesis, in its crude form, is not universally accepted, it nevertheless gives a fair conception of that part of the evidence with which we are now concerned. The process of evolution from cool to hot and then to cool again is fairly outlined. The nucleus of the original nebula has its modern representative in the Sun.

In all the foregoing discussion it has been tacitly assumed that the nebula from which the solar system was developed was similar in all essential respects to the planetary nebulae The latter, as shown by their spectra, consist mainly of hydrogen, helium, and nebulium, with slight traces in some of them of carbon, nitrogen, and perhaps other elements. Nebulium is known only from its lines in the spectrum, and its atomic weight has been estimated by Fabry and Buisson as 2 7, placing it between hydrogen and helium. In any further study of relations between the atomic weights of the elements, nebulium must be taken into account, and perhaps also coronium, so called from its lines in the spectrum of the solar corona. From its position in the corona it is assumed to be lighter than hydrogen, and so would seem to be an even more primitive element. That possibility cannot be considered here; we must limit ourselves to the conditions actually seen in the nebulae No assumption is made as to the possible ancestry of the nebular elements They are the visible beginnings.

Now it is easy to see that in the process of evolution from nebula to sun an orderly development of the elements could hardly have been possible. With changing temperatures, changing pressures, and changing environments all the conditions required for a regular progression according to the order of the atomic weights were lacking. The order actually followed was that of relative stability. In the hotter stars only the most stable elements were formed, and naturally in the greatest abundance. Calcium (atomic weight 40) and iron (atomic weight 56) were among the earliest to appear, while the others,

between helium (atomic weight 4) and iron, either came later or were developed at first in smaller quantities. As cooling went on more and more elements were generated, and in the Sun all the possible ones are presumably present. It is conceivable that elements of different stability may have been formed simultaneously, one in that part of the cooling mass where temperatures and pressures were highest, another further away from the center under less rigorous conditions. This, however, is something which cannot be proved. If the three nebular elements were the raw material from which the other elements were built, their relative amounts must have been continually changing, and so as each new element appeared a new environment was established for all that followed. How far these changes may have affected the evolution of the elements it is impossible to say, but in the evolution of compounds similar conditions would be significant.

That some of the chemical elements are very abundant, and others comparatively scarce, is a familiar fact which bears directly upon the theory of evolution Their relative abundance in known terrestrial matter has been repeatedly computed, by several workers and by different methods The results agree remarkably well, at least in the orders of magnitude as expressed in percentages This order, when we combine the figures for the lithosphere, the ocean, and the atmosphere, is as follows. First, oxygen, then silicon, aluminum, iron, calcium, sodium, potassium, hydrogen, and titanium, and these ten elements form at least 98 per cent of the whole. Only 2 per cent remains for all the other elements, some 80 or more in number [4]

For present purposes this estimate is obviously defective, for it covers hardly more than a thin film on the surface of the Earth and says nothing about the Earth's interior This objection is easily met if we take three facts into consideration. The Earth behaves like a huge magnet, it resembles a huge meteorite, and its mean density is double that of the rocks forming its crust. From these facts, and other quite minor considerations which need not be discussed here, we may fairly assume that the interior of the Earth contains a large proportion of metallic iron, and the quantity of it needed to give with the crust the mean density of the globe can be calculated. This has been done by others, and it now appears that in the Earth as a whole, iron predominates, oxygen and hydrogen fall to subordinate positions while the order of the other elements is little changed. Probably

[4] The details of the most recent computation of the relative abundance of the elements will appear in a joint paper by Dr. H. S. WASHINGTON and myself, which is in course of preparation.

nickel would appear among the first ten elements, but such a change will not affect our argument. Ten or eleven elements, all below 59 in atomic weight, exceed in abundance all the others. They are structurally among the simplest elements, and therefore, presumably the most stable.

These conclusions may now be applied to the hypothesis of evolution. The total amount of matter in the original nebula was of course finite; a large part of it was absorbed in building the simpler and more stable elements, and only what remained was available for the development of all the others. This conclusion, I admit, is largely speculative, but it is a legitimate interpretation of evidence. It may be modified by future investigations, but it is not likely to be completely overthrown. It is possible that the relative abundance of the elements may be different in different parts of the solar system, but it is not probable that any of the higher elements can find a place among the first ten. The whole scheme of evolution may be figured diagrammatically as a series of waves in which the crests represent the elements, and the depressions the gaps between them. In such a series the waves would reach their greatest height at iron, and then gradually flatten until the end where instability becomes most clearly evident

Between the evolution of the elements and their degradation there is a sharp contrast. The two processes do not follow the same path. Uranium does not decay to thorium, that to radium, then to lead, and so on down the line. The same divergence is shown between the synthesis and decomposition of compounds. It would be easy, for example, to effect a direct synthesis of calcium carbonate from its elements; but to reverse the process without the intervention of other substances would be extremely difficult. To cite a different example, trinitrotoluene, the T.N.T. of recent warfare, is prepared by the action of nitric acid on toluene, a relatively slow operation. On the other hand, when T.N.T. decomposes it does so instantaneously, and the products are oxides of carbon, methane, water, and free nitrogen. Something like this happens in the decay of a radioactive element, but with a difference; uranium, thorium or radium decomposes atom by atom; T.N.T. flies to pieces in mass. The one process is slow, the other extremely rapid.

I have already specified the external conditions which determine the stability of an element or compound, but when we consider the atom by itself, internal conditions are more important. On the

structure of atoms there is not as yet a complete agreement, and much remains to be done before the problem can be definitely solved. I cannot go into this subject in detail, but I may take it for granted that the conception of an atom as consisting of an electropositive nucleus attended by few or many electrons of opposite sign, is well established. In such a structure symmetry would be conducive to stability, and any deficiency in that respect would be unfavorable. For a simple element, with few electrons, symmetry would be most easily attained, for a complex element with many electrons it would be more difficult. Furthermore, an atom to be stable must show an exact balance between the electropositive and electronegative charges. With a single ring or shell of electrons the force of attraction holding nucleus and electrons together should be strongest, with concentric rings of electrons the outer ones would be more loosely held, and the atomic structure should be weaker. This seems to be the case with uranium and its neighbors. Here the structures are the most complex, and the number of electrons greatest. In short, the conditions, internal and external, which determine stability are by no means simple, and some of them operate in opposite directions They all agree, however, in favoring the evolution of the simpler elements and so render the fact of their greater abundance more intelligible.

When an atom of uranium decays, an *alpha* particle, which is an atom of helium, is first discharged, and with a very high velocity. By a succession of such discharges a series of products is generated, each one differing by four units in atomic weight from its predecessor. The atomic weight of helium is 4. Three of these products, omitting intermediate forms, are ionium, radium, and an "isotope" of lead. Ionium is isotopic with thorium, but not identical with it except in its purely chemical relations. The atomic weights are not the same. A similar difference is found for the lead derived from radium, which differs from normal lead in having an atomic weight about a unit lower. The isotope of lead in the thorium series differs from the normal by about the same amount in the opposite direction.[5] In short, the degradation path from uranium, and also that from thorium is approximately parallel to the path of evolution, but not identical with it. The short-lived products of radioactive decay might be described as the debris of exploding atoms. They do not appear in the ascending series of the elements.

[5] For a discussion of the nature of isotopic lead see CLARKE, Proc. Nat. Acad. Sci. 4 181. 1918.

For the elements below the radioactive group, that is, those of lower atomic weight, some evidence of instability has recently been obtained. Rutherford, by passing swiftly moving *alpha* rays through nitrogen, has observed a slight evolution of hydrogen, an indication that hydrogen is a constituent of the heavier and more complex element. Oxygen, treated in the same way, yields a product of different character, something which appears to have an atomic weight near 3. If, however, the value should be slightly lower, it would have a curious significance. Attention has already been called to the existence of nebulium, to which the atomic weight 2.7 has been provisionally assigned. This is very close to 2.666..., or $2\,^2/_3$ more precisely.

Now $2\,^2/_3 \times 6 = 16$, the atomic weight of oxygen, a relation which may possibly be experimentally verified. If the bombardment of oxygen were carried on for a long time it might yield a gas in which the spectral lines of nebulium could be detected; and if that were done it would be a step forward in the study of the atoms. I offer this suggestion with some hesitation, but it seems to be worth considering. It affects a number of other elements of which the atomic weights are multiples of 16.

By a remarkable series of experiments F. W. Aston[6] has obtained evidence which he regards as proof of the complexity of the atomic weights as determined by chemical methods Powerful positive rays in a magnetic field were applied to a number of elements, which then gave what he terms their "mass spectra." These spectra show lines corresponding to whole number atomic weights, which represent, not the accepted values, but some higher and some lower. Chlorine gives two such lines, corresponding to atomic weights 35 and 37, and mercury gives at least six, ranging from 197 to 204. The last two figures, I may add, are near the atomic weights of gold and thallium, that of mercury being 200.6. These new lines, as interpreted by Aston, represent isotopes, and the accepted atomic weights are regarded as mere statistical averages. In other words the atomic weights known to chemistry relate to mixtures, and are not true constants.

I must here allow myself to indulge in a very obvious truism. Whenever new phenomena are discovered an attempt is made to interpret them, and to bring them into relations with other phenomena.

[6] Science Progress 15: 212. 1920.

But it does not always follow that the first interpretation is the only one possible, nor even that it is the best. Now it seems to me conceivable, that the lines of Aston's mass spectra may really belong to decomposition products of the elements, produced by the disintegrating effect of the positive rays. This conclusion, I think, is more in harmony with chemical evidence than the one first proposed. It is, furthermore, sustained by the fact that the elements of high atomic weight seem to show as a rule more lines in their mass spectra than those low in the scale. The most complex elements should undergo the largest amount of disintegration. If the atomic weights as actually determined by the best modern methods are mere statistical averages of widely differing figures, then the elements must be regarded as variable mixtures, and uniformity could hardly be expected. This lack of uniformity would extend to all chemical compounds, which should vary in composition and also in physical properties; all chemical calculations would become inexact, and even the spectra of the elements would lose much of their significance Chaos would rule instead of order

In point of fact the evidence in favor of definiteness of atomic weight is much better than anything which has been adduced to the contrary. On that subject I could make a strong argument in support of my position, but I do not care to overload this paper with details. In discussing the evolution of the elements, and also their decay, I must take a pragmatic position and assume their integrity Their evolution follows an upward path, with which the downward path of decomposition is approximately but not exactly parallel The two paths, however, coalesce in the region of hydrogen, nebulium, and helium, and so the beginning and the end are the same. That hydrogen and helium are the chief constituents of the elements as we know them is possible, as Harkins in a long series of interesting papers has attempted to show. I cannot accept all his conclusions as final, although he has at least discovered some interesting relations Nebulium should not be left out of account.

On the mechanism of the process by which the elements were built up I have nothing definite to say. I can only ask questions If a heavy atom, like that of gold or mercury, is formed from simpler atoms, how are the latter changed? What happens to their nuclei and their electrons? Is the structure of the carbon atom the same in graphite and in diamond? Here the tetrahedral atom which plays so important a part in stereochemistry has to be considered.

With compounds these problems become much more complicated, that is, if we try to explain them in terms of atomic structure. Among organic compounds we find isomers and polymers, and many of them contain a hundred or more atoms to the molecule. How are their electrons rearranged, and what are they doing? All of these compounds, as I have already shown, are items in the general scheme of the evolution of matter, in which the question of atomic structure is fundamental. I have in this paper only touched the surface of a vast general problem, but my imagination has never wandered far from evidence and reasonable analogies. Perhaps I have made suggestions which may lead others to the discovery of new truths.

MINERALOGY.—*On galenobismutite from a gold-quartz vein in Boise County, Idaho.*[1] EARL V. SHANNON, Department of Geology, United States. National Museum. (Communicated by E. T. Wherry).

The mineral galenobismutite, first described by Sjögren from the Ko Mine, Nordmark, Sweden[2] has not heretofore been definitely identified at any second locality. The material from Fahlun, Sweden, described by Atterberg[3] contains more selenium than sulfur and is doubtless either a mixture or a variety of weibullite or platynite. It is listed as a distinct species by Hintze[4] under the name "selenbleiwismuthglanz."[4] Alaskaite, included by Dana under galenobismutite, is regarded by Hintze and also by Wherry and Foshag as a distinct species.[5] The lead sulfo-bismuthite from the tungsten veins of Deer Park, Washington, analyzed by R. C. Wells and described by Bancroft[6] as intermediate between galenobismutite and cosalite is quite probably distinct from either It thus appears that galenobismutite, properly so-called, is an exceedingly rare mineral. For this reason it becomes of interest to note that this mineral occurs as a constituent of a gold ore from Idaho preserved in the United States National Museum.

[1]Published by permission of the Secretary of the Smithsonian Institution. Received May 25, 1921

[2] H SJÖGREN. Geol Foren Forh 4: 109. 1878.

[3] ATTERBERG Geol Foren Forh 2: 76 1874

[4] C. HINTZE *Handbuch der Mineralogie*, 1: 1012.

[5] E T WHERRY and W F. FOSHAG *A new classification of the sulfo-salt minerals*. This JOURNAL 11: 1-8 1921.

[6] HOWLAND BANCROFT. *Notes on tungsten deposits near Deer Park, Washington.* U. S. Geol. Survey Bull 430: 216. 1910

The specimen was collected by Edward L. Jones, Jr., of the U. S. Geological Survey and is included in an unstudied collection of ores from southern Idaho. The label gives as the field number SI-106, and as the locality, Belzazzar Mine dump, Quartzburg district. The specimen was collected September 15, 1915. Regarding the Belzazzar Mine, Lindgren states that it is located on the Fall Creek side and has been opened by sluicing and a tunnel, 200 feet below the summit. Bodies of heavy sulfurets, chiefly pyrite, are exposed along the vein. The western part of the vein lies in hornblende porphyrite, while the eastern end has granite in the footwall and the same porphyrite in the hanging wall.[7] Bell gives the location of the mine as near the Jerusalem Valley road, a little west of Quartzburg.[8] He states that the ore is merely an altered phase of the enclosing rock traversed by quartz seams. The ore was free-milling on the first and second levels and produced fine specimens of free gold. The third level, however, showed considerable amounts of sulfides and only half of the gold in this sulfide ore was recoverable by amalgamation. The ore is said to average from $8.00 to $12.00 per ton.

The specimen which contains the galenobismutite consists in the main of translucent to transparent crystalline white vein quartz. The sequence of deposition of the minerals is not entirely clear but there is a band of more or less pure pyrite adjacent to the wall of the vein and this pyrite appears to be the earliest mineral of the ore. The quartz is slightly sheeted parallel to the vein wall, small grains of pyrite being distributed along the partings. Pyrite occurs also in crystalline grains through the quartz and also as sharply bounded cubic crystals in greatly sericitized fragments of wall rock which occur in the quartz. The quartz is loose textured and contains small angular cavities between the crystals. The galenobismutite occurs interstitially with relation to the quartz crystals and projects as fibrous bundles of prismatic needles into the cavities. It is clearly the youngest mineral of the vein, the common paragenetic position of the majority of the lead sulfo-salts.

The galenobismutite is rather light gray in color and tarnishes to a yellowish color. Its luster is rather more brilliant than that of the antimonial sulfo-salts of lead, and the mineral greatly resembles bismuthinite in general appearance It forms elongated prisms im-

[7] WALDEMAR LINDGREN *Mining Districts of the Idaho Basin and Boise Ridge, Idaho* U. S. Geol Survey, Ann Rept. 18, Pt. III: 690 1896–97.

[8] ROBERT N BELL. Rept. Idaho State Inspector of Mines for 1905, p. 33

bedded in quartz or minute, deeply striated crystals in open cavities. The streak is black on porcelain or brownish black when rubbed very thin with a glass rod. The hardness is about 2.5.

Material for analysis was secured free from impurities other than quartz and a little pyrite, both of which remained unattacked when the mineral was dissolved in hydrochloric acid. The material was found to be free from other impurities by examination of polished surfaces under the miscroscope. Standard methods of analysis were used, the bismuth and lead being separated by the basic nitrate method. It is noteworthy, however, that this method, which is the one recommended by most textbooks, is one which gives satisfactory results only when performed with extreme care. The major separation was accomplished by precipitating the bismuth by means of hydrogen sulfide in strongly acid solution, the precipitate being almost free from lead while very little bismuth remained in solution. The separation by the basic nitrate method was repeated several times on each product of this separation before these two metals were obtained free from each other. The material available for analysis was too small to permit sulfur to be determined. The results of the analysis, recalculated after deducting gangue, are given in table 1.

TABLE 1

ANALYSIS OF GALENOBISMUTITE FROM IDAHO

		Per cent	Calculation of Ratios		
Lead	Pb	23 93	0 1155		
Iron	Fe	39	0 0057	1434	1 03 × 1
Copper	Cu	1 73	0 0272		
Antimony	Sb	2 56	0 0213	2789	1.00 × 2
Bismuth	Bi	53 59	0 2576		
Sulfur (calculated)	S	17 80	0 5550	5550	1 00 × 4
Total		100 00			

The formula thus derived is:

$$\text{Pb Bi}_2\text{ S}_4 \text{ or PbS Bi}_2\text{S}_3.$$

The copper, iron, and antimony, while present in minor amount, merit note Copper and iron while probably not entirely isomorphous with lead, can perhaps enter into solid solutions in limited amount, the copper in all probability being in the cupric state. It is possibly significant that copper and iron are molecularly roughly equivalent to the antimony and may be combined with it. Such an amount of copper and iron compounds might conceivably be present as submicroscopic inclusions in the galenobismutite.

BOTANY.—*A remarkable new species of* Ichthyothere.[1] S. F. BLAKE, Bureau of Plant Industry.

The genus *Ichthyothere* of the *Asteraceae* is of some economic importance among the native tribes of South America, since the bruised leaves and stems, placed in water, possess the property of stupefying fish and rendering them easy to capture. This property is shared with the closely allied genus *Clibadium* and with many other genera of various families, among which the *Fabaceae* and *Sapindaceae* are conspicuous.

Ichthyothere itself, as at present constituted, contains about a dozen species, all South American. All are low herbs or suffrutescent, with the few small whitish discoid heads in close clusters at the tips of the stems. In most species the heads are sessile, but in a few they are distinctly pedicellate.

While engaged in the preparation of a key to the species, I found in the National Herbarium a specimen from Colombia, doubtfully referred to this genus, and differing from all the species hitherto described in its loosely racemose-panicled heads and climbing habit. Through the courtesy of Dr. F. W. Pennell, the collector, I have had for study the more complete specimen of the same collection in the New York Botanical Garden. Detailed comparison with specimens of **Ichthyothere terminalis** (Spreng.) Blake,[2] the type of the genus, shows that its differences in habit and inflorescence are not associated with any important difference in technical characters, and, although so distinct in appearance, the plant is best considered a species of *Ichthyothere*. It may be recognized by figure 1 and by the following description.

Ichthyothere scandens Blake, sp. nov.

Shrubby vine, stems slender, branching, obscurely sordid-pilose with appressed hairs, glabrescent; leaves opposite; petioles slender, sparsely sordid-pubescent, 3 to 10 mm. long. blades ovate or lance ovate, 7 to 11 cm. long, 2 to 4 5 cm. wide, falcate-acuminate, at base acute or acuminate, finely serrulate, membranaceous, green on both sides, sparsely sordid-pubescent on the veins, glabrescent, tripli- or quintuplinerved; panicles axillary and terminal, very loose, dichotomous, obscurely puberulous, 16 cm. long or less, bracts minute, about 1.5 mm. long; heads loosely racemose along the branches, on pedicels about 4 mm. long, compressed, 4.5 mm. high, 5.5 mm. wide in fruit; outer phyllaries 5, subulate-triangular, coriaceous-herbaceous,

[1]Received May 31, 1921.

[2]*Rolandra terminalis* Spreng. Syst. Pl. 3 673 1826, *fide* BAKER in Mart Fl. Bras. 6[3] 154 1884 *Ichthyothere cunabi* Mart in Buchn Rep. Pharm 35 195. 1830. For full synonymy see BAKER, *loc cit*

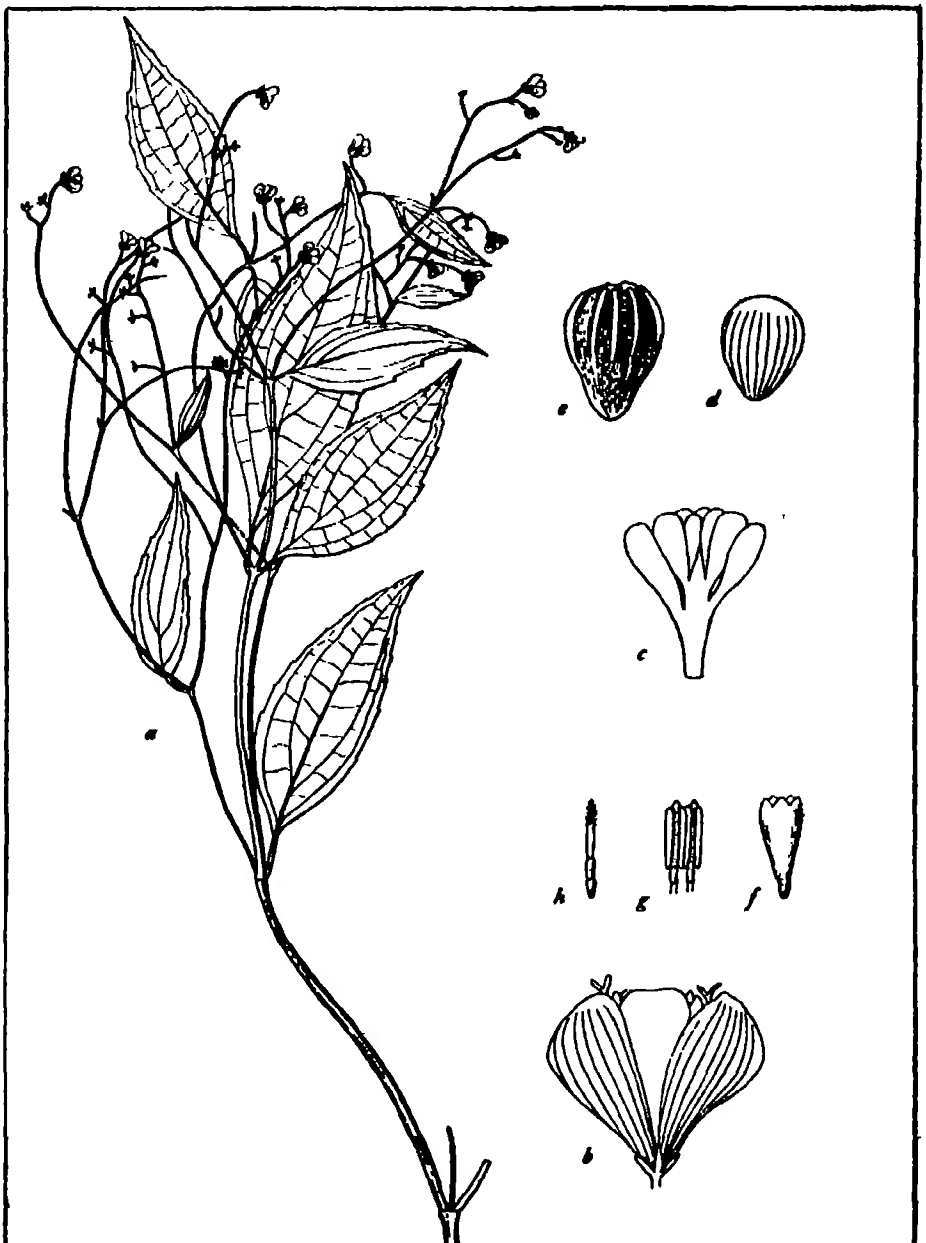

Fig. 1. *Ichthyothere scandens* Blake. *a*, branch, × 1/2; *b*, head, × 5; *c*, receptacle and pales, × 5, *d*, phyllary subtending female flower, × 5; *e*, achene, × 5; *f*, disk flower, × 5; *g*, stamens, × 5; *h*, disk flower with corolla and stamens removed, showing ovary, gland surrounding base of style, and style, × 5.

ciliate, 1 mm. long; inner phyllaries (subtending the female flowers) 2, obovoid, subherbaceous with thin margin, obtuse, glabrous, many-nerved, 5.5 mm. long; receptacle stipitate, bearing nine hermaphrodite sterile flowers; female flowers 2, their corollas tubular, annulate-pilose at apex, very short, corolla of the hermaphrodite flowers tubular-funnelform, greenish-white, 1.8 mm. long; achenes obovoid-turbinate, thick but somewhat obcompressed, truncate, about 8-ribbed, glabrous, 4.2 mm. long, pales of the disk suborbicular-cuneate to (inner) cuneate, glabrous, truncate or rounded, many-nerved with thinner apex, 2 to 3 mm. long.

Type in the U. S. National Herbarium, no. 1042822, collected in forest at Libano, Department of Tolima, Colombia, altitude 1100 to 1300 meters, December 26-29, 1917, by F. W. Pennell (no. 3430). Duplicate in the herbarium of the New York Botanical Garden.

Although in all its technical characters this species is clearly a member of the genus *Ichthyothere*, it is very distinct from all the previously known species in its scandent habit and its very loose inflorescence.

RADIOTELEGRAPHY.—*A chronographic recorder of radio time signals.*[1] E. A. ECKHARDT and J. C. KARCHER, Bureau of Standards. (Communicated by S. W. Stratton).

The problem of recording radio signals is one of amplifying the feeble energy in the radio signal to such a degree that in the amplified amount it is sufficient to operate a recording device. Whether the recording be done photographically or by means of some form of stylus, the electrical energy of the radio signal at some stage of the process gives rise to a mechanical motion. The aim of the experimenter is to make the chain of events between the receiving antenna and the mechanically moving element, as well as the apparatus embodying it, as simple and reliable as possible. If it is desired to use the recording apparatus in field service these considerations are especially important. Ruggedness then becomes an additional imperative requirement. The recording apparatus described in this paper was intended primarily for field use, since with it the U. S. Coast and Geodetic Survey wishes to record Annapolis time signals at any field station which it may desire to occupy within the borders of the United States.

So far as we know, success in recording radio signals at long range has heretofore been attained only by the use of amplifiers of many stages. Despite the great progress which has been made in the design and construction of such devices, a field party, which needs to give considerable attention to the weight of its equipment and which in general is not accompanied by a qualified radio engineer, will not

[1] Presented before the Philosophical Society of Washington, March 26, 1921 Received May 5, 1921.

contemplate their use with any degree of confidence. When a multiplicity of electron tubes is used the storage battery equipment presents a serious problem to the field party. Either the battery must be of large capacity or provision must be made for frequent charging. If, therefore, any radio receiver-recorder is to be available for service in the field, keeping the number of tubes down to a minimum is an important consideration.

The nucleus of our receiver-recorder is the regenerative circuit shown in figure 1. It consists of a capacity C_1 and inductance L_1 in the grid circuit of the electron tube, the inductance L_1 being coupled to the inductance L_2 in the plate circuit of the tube. In order that the circuit may be regenerative the coupling must be of such sign that a rise in plate current results in a rise in the grid potential. The potentiometer P serves to adjust the mean grid potential over a suitable potential range, both negative and positive.

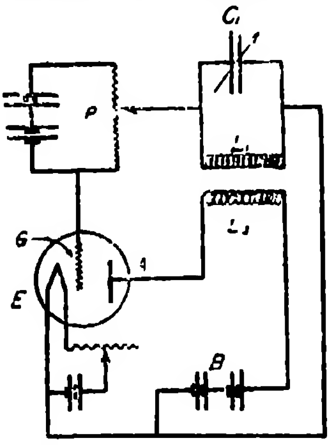

Fig. 1. Regenerative circuit

Such a circuit is capable of acting as a generator of electrical oscillations. The frequency is determined in the main by the inductance capacity combination L_1 C_1.

If, by adjusting the potentiometer P, the grid potential is gradually made more and more negative, the oscillations are stopped. Upon gradually raising the potential it will be found that there is a critical grid potential at which the oscillations set in. This grid potential is characteristic for the circuit used.

Figure 2 shows a plate current-grid potential, characteristic of a typical receiver type electron tube. If the grid be at a mean potential corresponding to the point C_r and an alternating e m f be applied to it, the increase of plate current during the positive half of the cycle will be greater than the decrease during the negative half. This is due to the curvature of the characteristic. Thus the mean value of the plate current is increased by the periodic e m f. on the grid. If C_r is the critical point on the characteristic at which the circuit becomes self-oscillatory, the amplitude of the periodic component of the grid potential builds up; likewise the amplitude of the periodic plate cur-

rent, and there results a rise in the mean plate current as shown by figure 2. By proper design, conditions may be so chosen that the rise in plate current occasioned by the initiation of oscillations in the regenerative circuit is many times the plate current flowing just be-

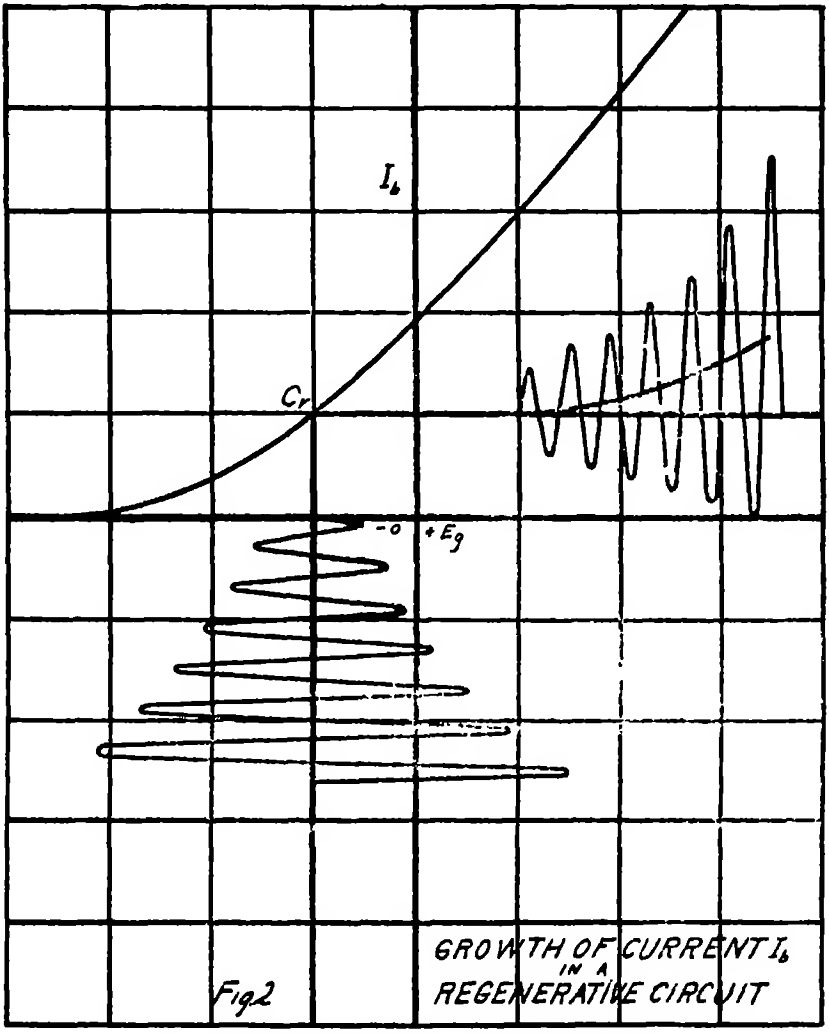

Fig 2. Growth of current in a regenerative circuit

fore the oscillations set in. Regenerative circuits have been operated by us in which the plate current shoots up from 2 or 3 milliamperes to 50 milliamperes when by raising the grid potential a small fraction of a volt the circuit is made to pass from the non-oscillatory to the oscillatory state. In our recorder the rise is from approximately $^1/_4$

milliampere in the non-oscillatory to 2 milliamperes in the oscillatory state.

The rise in mean plate current which accompanies the starting of the oscillations is an important feature from the point of view of recording radio signals. An ordinary telegraph relay which will operate on one or two milliamperes may be introduced into the plate circuit. The starting of the oscillations will cause the relay to function and the relay contact may be used either to open or close a local circuit. If the local circuit is one operating a chronographic pen the starting of the oscillations may be chronographically recorded.

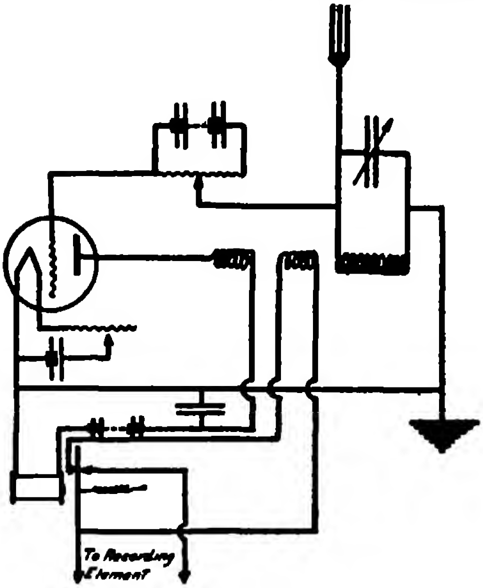

Fig 3. Radio recording receiver.

Now the change in grid potential necessary to pass from the nonoscillatory to the oscillatory state is very small, so small indeed that it may be provided by a radio signal received on an antenna suitably connected to the grid of the electron tube of the regenerative circuit. Figure 3 shows a suitable arrangement for this purpose. The antenna leads to the tuned circuit which is connected to the grid of the tube through the potentiometer. The inductance of this tuned circuit is coupled regeneratively with an inductance in the plate circuit. The function of the intervening coil we shall consider presently. The oscillations due to the incoming radio signal cause the grid potential to vary periodically about its mean value. If this mean value is just below the critical one peculiar to the regenerative circuit the incoming signal will cause the critical value to be reached, and local oscillations will be initiated. Unfortunately, however, the local oscillations persist even after the mean grid potential has been restored to its original value below the critical one. To stop these oscillations by changing the grid potential it would have to be lowered considerably below the critical value. We are, therefore, thus far possessed of the means

for setting up local oscillations by the incoming signal, but the instrument does not automatically reset itself.

Means must be provided for killing the local oscillations as soon as the periodic potential variation of the grid has ceased, *i.e.*, when no signal is being received. For this purpose the telegraph relay in the plate circuit is provided with a second contact, insulated from the first, which

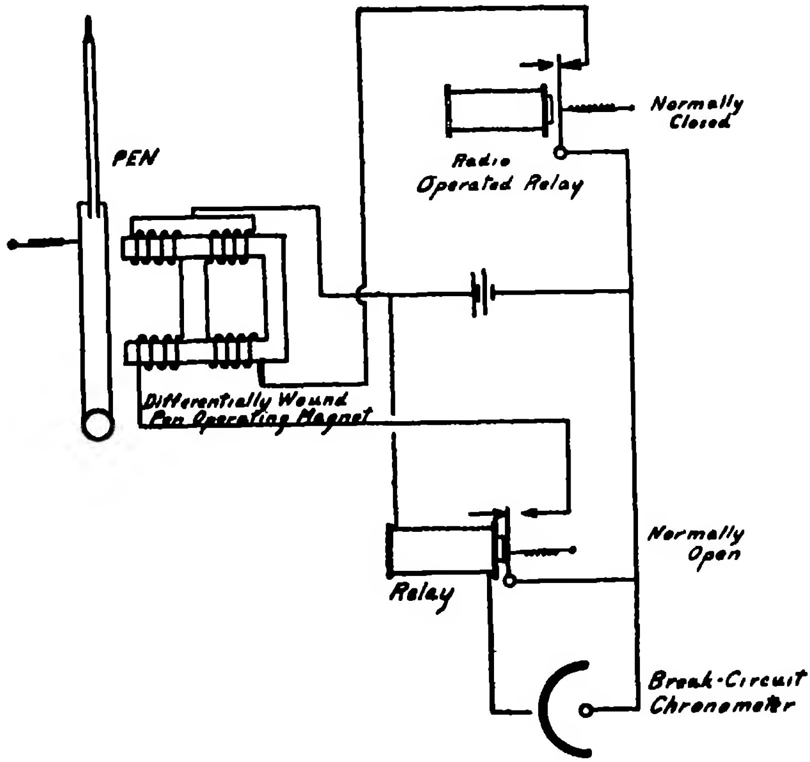

Fig. 4.

is closed when the relay armature is attracted by the relay magnet. The closing of this rear contact short-circuits a low resistance coil of a few turns mounted between the regenerating coils. When short-circuited, this coil provides an effective screen between the grid and plate inductances and regeneration is promptly stopped. The stopping of the local oscillations occasions a decrease in the plate current, the relay armature is released and the oscillation-stopping contact is opened. If the potential oscillations of the grid still persist as the armature is leaving the rear contact the local oscillations will immediately build up, the mean plate current will rise, and the relay armature will be

attracted to the relay magnet before it gets far enough away to make the outer, pen-controlling, contact. Thus, during a long dash signal the relay armature simply chatters against the rear contact, without at any time moving far enough to make the outer one. It is clear, therefore, that during the arrival of the signal the relay armature is chattering against the rear contact and between signals it rests against the front one.

Figure 4 shows the front contact of the telegraph relay normally held closed by the tension spring. The starting of local oscillations causes the relay to operate in the manner previously described, the front contact opens and the rear one closes. The opening of the front contact operates the chronograph pen, and the closing of the rear one short-circuits the oscillation-choking coil. The making of the rear contact, therefore, stops the oscillations, causes the plate current to fall back to the non-oscillatory value, the relay to release and the front contact to close.

If a continuous dash signal is being received the local oscillations build up as soon as the relay armature leaves the rear contact, and it is drawn back before the front contact is remade. Thus the chronograph pen continues in the released position until the signal stops long enough for the relay armature to remake the front contact. With no signal coming in, the front contact of the relay is closed and the chronograph magnet is energized. The pen-carrying armature is, therefore, held against the inner stop When the incoming signal begins, the front contact is opened, the chronograph magnet is deenergized and the pen-carrying armature is released against the outer stop. It remains against the outer stop until the front contact of the plate circuit relay is again made. The pen then returns to its initial position against the inner stop.

In the recorder design now in use, a single stage of radio frequency amplification is provided so that the signal oscillations may be amplified before being applied to the grid of the tube in the regenerative circuit. This preliminary stage of amplification increases the overall sensitivity somewhat, but the regenerative circuit itself and the manner of its use account for all but a few per cent of the total sensitivity attained

The preceding account describes a complete mechanism for recording radio signals. A similar recording system has recently been described by Captain L. B. Turner[3]. His methods of stopping the local oscil-

[3] The Electrician 83: 4. July 1919.

lations involve readjustments in the regenerative circuit when the oscillation-stopping contact is opened. If, for example, the plate inductance is short-circuited for the purpose of stopping the local oscillations, the removal of the short involves reëstablishment of a difference of potential at the terminals of this coil. This causes a surge which tends to restart the oscillations and results in the recording of a spurious signal. The method employed by us of stopping the oscillations involves no readjustments in the regenerative circuit when the oscillation-destroying contact is opened and the system is restored to the receptive state. We are, therefore, enabled to work very much nearer the critical grid potential with correspondingly enhanced sensitivity.

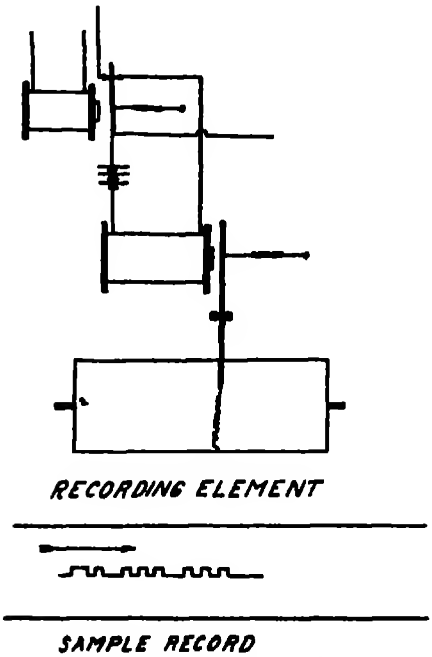

Fig 5. Circuit recording element.

It is proposed to use the radio time recorder for the determination of the longitude of any station This may be done by comparing in turn the local time ascertained by star observations and the radio time signal from a known longitude with a local chronometer. It is, therefore, necessary to make simultaneous records on a chronographic drum of

1. Local star transits against local chronometer
2. Radio time signals against local chronometer.

From the data thus obtained, the longitude of the unknown station may be computed with reference to that of the radio time signal sending station.

It is obviously desirable to have the same lag in the recording apparatus for both signals. If, therefore, both can be recorded by means of the same mechanical system, *i.e.*, with the same pen, a serious cause of difference in lag has been eliminated. How this has been accomplished is illustrated in figure 5. The pen-operating magnet is differentially wound with two coils of approximately equal resistance and equal number of turns. The break-circuit chronometer operates a relay similar to that in the radio recieving-recording set. The clock-

controlled relay energizes one of the pen magnet coils during the brief period of the clock break. If the pen is in the released position during the clock break the pen magnet is momentarily magnetized and the pen is momentarily moved against the inner stop. If the pen is in the attracted position the clock break will serve to demagnetize the pen magnet momentarily and the pen will be released against the outer stop during the break. The pen will record the clock break, therefore, no matter what its status with reference to the radio signal.

When star transits are to be recorded simultaneously with a local chronometer, the pen magnet winding previously utilized for the recording of the radio signals may be included in a local signaling circuit. The tapping of the signal key then operates in a manner similar to the starting of a radio signal.

Oscillographic study of the performance of a regenerative circuit with a telegraph relay with double contact in the plate arm and with the screening coil for stopping the regeneration, has shown that the oscillations are started and stopped well within 0.001 second. Figure 5 shows clearly that on the one hand we have a chain consisting of antenna—relay—pen circuit—pen, and on the other, chronometer—relay—pen circuit—pen. The two relays are similar and their reaction times are less than 0.001 second. Their difference will be considerably smaller than this amount. The pen circuits are also similar, and finally the pen is identical.

It is seen clearly that the system has been designed to minimize the lag difference of the two kinds of signals. Since comparisons of two different kinds of signals are to be made, it is only the consistency and magnitude of the lag difference which is of importance. Measurements of this quantity are to be made in a number of receiving-recording sets prior to their use in the field. The U. S. Coast and Geodetic Survey proposes to obtain an additional check by occupying a station of precisely known longitude and working the problem backwards. Thus the lag will be subjected to independent measurement in the laboratory and in the field. It is confidently expected that by the use of this recorder a new order of precision will be attained in measurements of the kind in which this apparatus may be employed.

BIBLIOGRAPHY

Simon, Hans. Jahrb. drahtl. Telegr. 2. 409–416. 1908–09.
Turpain, A Rev Electrique. 18: 211–214. Sept. 1912.
Turpain, A. Bull Soc. Int. des Electr. (3) 3: 299–322. 1913.
Abraham, H Bull Soc. Int. des Electr. (3) 3 649–662. July 1913.
Campbell-Swinton, A. A. Proc. Wireless Soc. London, 1914.

DOANE. Compt. Rend. 158: 473-474 1914
RAYMOND-BARKER, E. Electrician 72 743, 744 and 783. 1914
WAGGONER, C. W. Phys. Rev 3· 500 1914
RAINEY, R M. Electr. World 65 848 1915.
LENNER, E. Electro. techn Zeitschr 36· 598 1915.
URIE, F D. Pop. Astron 23. Nov. 1915
POULSEN, R. M. Electr World 68: Nov 1916
CULVER, C A. Journ. Frankl Inst. 187 May 1919.
ABRAHAM, BLOCH Compt Rend 169: 282-285 Aug. 1919.
CAMPBELL-SWINTON, A. A Wireless World 8: 641-648. Dec. 1920.
TURNER, L. B. Electrician 83: 4, 5, 34, 35, 554-557. 1919.
HOXIE, J. A. Elektrotechn Zeitschr 41: 733-734 Sept. 1920.
CREED Co LTD. and D McLENNAN. The Engineer 130: 366. Oct. 1920.
LATOUR, M L'Electricien 51: 452 Oct. 1920
HOXIE, J. A. Radio Rev. 1: 781 Dec. 1920
CAMPBELL-SWINTON, A A. Sci Amer. Monthly 3: 155-156. Feb. 1921.
COURSEY, P P Wireless World 8: 761-764. Feb. 1921
WALLACE, S T. Wireless World 8: 768-769 Feb. 1921
BRUN, J. Radio Electricité 1: 477-487 March 1921
PRATT, H Proc Soc. Rad Eng 9: 174 Apr 1921

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

OPTICS.—*The contrast sensibility of the eye as a factor in the resolving power of the microscope.* FRED. E. WRIGHT. Journ. Opt. Soc. Amer. 2:101-107. 1919.

In this paper three factors of importance in high-power microscope work are emphasized, namely. (1) The use of a polarizing prism to eliminate that part of the field-light which does not contribute to the diffraction pattern in the image and hence tends to reduce the contrast and to decrease the sharpness and crispness of the image. This phenomenon arises because diffracted beams, which emerge from gratings whose interval is of the order of magnitude of half a wave length of light, are sensibly polarized in a plane normal to the lines of the grating. (2) a Diaphragm of the rectangular type, for use in the image plane of the eyepiece in order to cut out all light except that from the particular object under examination. The field should, however, cover at least 10°. (3) The importance of a field intensity of illumination approaching that of daylight and best adapted for the eye at any particular time. The simplest method for securing this is by means of a substage polarizer in conjunction with the polarizing prism; the polarizer can be rotated, and with it the intensity of illumination of the field varied. These factors are not important for ordinary observations, because the resolving power there required is not great; but in high-power, critical work they are significant and enable the observer to accomplish with comparative ease that which under other conditions is a matter of difficulty. F. E. W.

GEODESY.—*Latitude developments connected with geodesy and cartography, with tables, including a table for Lambert equal-area meridional projection.* OSCAR S. ADAMS. U. S. Coast and Geodetic Survey Spec. Publ. **67.** (Serial **143**) Pp. 132. 1921.

There are six different kinds of latitude that are found convenient in various cartographic and geodetic applications. In this publication the developments of the differences between each of these latitudes and the geodetic latitude are derived in Fourier series in terms of the geodetic latitude and afterwards expressed in terms of the particular latitude in question. In the case of two of the latitudes that are, from their definitions, somewhat complicated in their development, the series have been derived in several different ways. This procedure serves as a check upon the work and the methods in themselves are interesting applications of analysis to practical problems.

The coefficients of the series are expressed in terms of the eccentricity of the meridian ellipse, in this form they are applicable to any spheroid of reference For the computation of tables, these coefficients were afterwards expressed in terms of the Clark spheroid of 1866, this being the spheriod of reference of the North American Geodetic Datum. In this form the coefficients are given in seconds of angle so that the result of a computation may be expressed in seconds of angular measure. The resulting coefficinets are given both as numbers for use in machine computation and as logarithms for work without calculating machine.

Tables are included for these latitudes computed for every half degree of latitude In practical applications, these tables will be found of very great advantage since they give results that would require a great amount of computation if no table were available.

In addition to these latitude tables, there are given tables for transformation from latitude and longitude to arc distance and azimuth from a point on the equator After these is given a table of the radial distance for a Lambert azimuthal equal-area projection upon a meridian plane, and finally there is included a table of the coordinates for this projection. O. S A.

ZOOLOGY.—*Report on the Crinoids collected by the Barbados-Antigua Expedition from the University of Iowa in 1918.* AUSTIN H. CLARK. Univ Iowa Studies. Studies in Natural History, **9** (First Series No 45), 5, 1–28 March 15, 1921.

The crinoids collected by the Barbados-Antigua Expedition are minutely described, a history of the development of the study of the West Indian crinoids is given, and the faunal characteristics and relationships of the Caribbean region are discussed in detail, a key to the 30 genera of crinoids occurring in the Caribbean Sea is included, the author's 25 previous papers on the Lesser Antillean fauna (dealing with living and extinct birds, mammals, amphibians, fishes, insects and onychophores) are listed. A. H. C.

METALLURGY —*The intercrystalline brittleness of lead* HENRY S. RAWDON. Bur. Standards Sci Paper **377**. Pp. 19, figs. 11. 1920.

Sheet lead sometimes assumes a very brittle granular form during service, dne to corrosion An explanation which has been offered by previous investigators for this change in properties is that it is due to an allotropic transformation, the product resulting from the change being analogous to the well-known "gray tin." The rate at which the intercrystalline brittleness is brought about is proportional to the amount of impurities and to the concen-

tration of acid in the solution in which the lead is placed. Practically all the impurities which are found in lead are lodged between the grains. The preferential attack by the corroding agent for these impurities and perhaps also for the "amorphous intercrystalline cement" accounts for the brittleness produced. Investigation showed that specimens of exceptionally pure lead (99.993 per cent), when immersed for 24 days in a neutral solution of lead acetate, became appreciably embrittled by the formation of minute intercrystalline fissures. No evidence of the existence of an allotropic form of lead similar to gray tin could be obtained. H. S. R.

CHEMICAL TECHNOLOGY.—*Inks—their composition, manufacture, and methods of testing.* Bur. Standards Circular 95. Pp. 24. 1920.

The composition and manufacture are discussed only briefly, but the methods of testing which are in use at the Bureau of Standards are given in sufficient detail to enable any chemist to use them. After a brief introduction on the history of ink, there are discussions of writing and copying inks, ink tablets and powders, marking, cancelling, stamping, duplicating, and sympathetic inks. The methods used for the laboratory examination of all but the last of these kinds of ink are next taken up. The circular closes with a short bibliography.

RADIOTELEGRAPHY.—*Principles of radio transmission and reception with antenna and coil aerials* J. H. DELLINGER. Bur. Standards Sci. Paper 354. Pp. 63, figs. 17. 1919.

Coil aerials are coming to replace the large antennas in radio work. It is found that the coil aerial is particularly desirable for communication on short wave-lengths. A coil aerial is as powerful as an antenna only when its dimensions approach those of the antenna. For other reasons, however, a small coil aerial is in many cases as effective as a large antenna. An advantageous type of radio aerial is a condenser consisting of two large metal plates. This type of aerial has many of the advantages of the coil aerial. The fundamental principles of design of aerials are given in this paper. On the basis of this work the actual functioning of any type of radio aerial can be determined either from measurements made upon the aerials or from actual transmission experiments. J. H. D.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

848TH MEETING

The 848th meeting was held in the Assembly Hall of the Cosmos Club on March 12, 1921. It was called to order by President FARIS, with 43 persons present. The program was as follows.

T. S. SLIGH, JR. *Recent modifications in resistance thermometer construction.* (illustrated.)

A resumé of some of the more important phases of resistance thermometry led up to a brief discussion of present practice at the Bureau of Standards regarding the construction of resistance thermometers.

The most important points regarding present practice including recent modifications are: (1) The use of the potential terminal type of thermometer with Wheatstone bridge. (2) Thermometer leads made of 12 strands of No. 28 copper wire instead of the fine flexible strand previously used. (3)

Thermometer bridge terminals of thin copper. (4) Smaller and neater thermometer heads. (5) Sealing of the strain-free type of thermometer. (6) Elimination of the drying head on calorimeter thermometers. (7) A method of electrical annealing which seems to effectively relieve all winding strains in the thermometer coil. The subject matter of the paper is given in full in Bureau of Standards Scientific Paper No. 407.

The paper was discussed by DR. W. P. WHITE.

R. H. WILHELM and AMELIA K. BENSON: *A comparison of the International Hydrogen Scale with the standard scale of temperature defined by the platinum resistance thermometer.* (Illustrated; presented by Miss Benson.)

The International Scale of Temperature adopted by the International Committee on Weights and Measures in 1887 is the scale of the hydrogen thermometer set up by Chappuis at the International Bureau, the pressure of hydrogen at 0° C. being one meter of mercury. Chappuis calibrated four verre dur thermometers so as to define the mercury-in-glass scale, and compared these thermometers with his hydrogen thermometer to get the correction necessary to convert the verre dur scale to the hydrogen scale. Since the platinum resistance thermometer has proved to be a more reliable primary standard than the verre dur thermometer, it was decided to compare all the verre dur primary standards of the Bureau with platinum thermometers, and then place the verre dur thermometers in the vault.

The two scales have been compared by Griffiths in 1893, Waidner and Mallory in 1899, Harker and Chappuis in 1900, and the Bureau of Standards in 1917 and 1920. All the comparisons indicate that the hydrogen scale is lower than the standard platinum scale by perhaps 0.010 degree in the range 10° to 30° C.

The paper was discussed by Messrs BURGESS, FENNER, HARPER, SOSMAN, MILLAR, SLIGH, and DICKINSON. The President announced that Miss Benson had the distinction of being the first woman who had ever addressed the Society

C. O. FAIRCHILD *New methods of sealing optical glass.* (Illustrated.)

A new process for joining optical glass has been developed which enables one to join glass parts with finished surfaces without distorting the surfaces except at an edge. It has been applied to the construction of colorimeter tubes, cells, etc., polarimeter tubes, incandescent lamps with optical glass windows, haemacytometers, and Nessler tubes, and the protection of surfaces for internal reflection.

The method is carried out by heating the glass parts while in approximate contact, in an electric furnace, to a temperature at or near the annealing range, and applying heat locally (usually at an edge) by means of a small oxy-gas flame. The progress of joining is viewed through a window in the furnace.

The process was developed through consideration of the low thermal conductivity of glass, and the rapid change in mobility near annealing temperatures. These properties make it possible to start fusion by local heating without propagating stress beyond a very restricted portion of the glass.

It has been found that two polished surfaces nearly in contact will join readily when junction is once started and it is possible to obtain excellent results without polishing the surfaces. A fine ground surface provides a good joint and the fusion is accomplished with almost complete disappearance of the ground part.

The method has proven to be the simplest and most satisfactory so far developed for the sealing of glass without distortion. It is, of course, particularly adapted to thin walled articles such as absorption cells and boxes.

The paper was discussed by Messrs. WHITE, FENNER, SOSMAN, CRITTENDEN, and others.

H. H. KIMBALL, *Recording Secretary.*

BIOLOGICAL SOCIETY

620TH MEETING

The 620th meeting was held in the lecture hall of the Cosmos Club on February 5, 1921, with President HOLLISTER in the chair and 50 persons present. On recommendation of the Council, Mr. GLENWOOD C. ROE and Mr. MAURICE K. BRADY were elected to membership. The deaths of Mr. W. J. BENNETTS on September 13, 1920, and Mr. W. W. WELSH on January 31, 1921 were announced, both having been members of the Society.

Informal Communications

Dr. H. M. SMITH exhibited a string of artificial pearls, and a bottle of finely comminuted fish scales in suspension. The industry of making artificial pearls was transferred to this country during the war, the Bureau of Fisheries assisting by suggesting fish whose scales were of desirable luster. Dr. Smith also exhibited the smallest and consequently the youngest eel ever captured. It was 2 cm. long, taken at 150 meters depth about 150 miles southeast of the Bermudas. This is the locality where fresh water eels of Europe and America resort to breed. The specimen was taken by Dr. SCHMITT in his recent expedition to study eels.

Dr. R. W. SHUFELDT stated that in his studies of birds and mammals fractured bones are sometimes found. An instance in *Oxymicterus rufus*, a large mouse from Brazil, was described, in which the greatly extended olecranon or elbow process of the forearm was broken, and a false joint had formed.

Regular Program

IVAR TIDESTROM: *Notes on the flora of the Iberian Peninsula.*

Mr. Tidestrom showed that Spain possessed 60 per cent of Europe's 10,000 species of plants, many of which are peculiar to Spain, and explained this fact, as well as the relation of Spain's flora to that of other countries, by her more continuous elevation above sea level in the later geological periods. The resemblance of Spain's topography to that of our own Southwest, and the similarity of climatic and botanical zones, was shown in detail. The paper was illustrated by maps, topographic sections, and landscapes.

R. S. BASSLER: *Paleontological work at the National Museum.*

The work of the National Museum is divided into three principal fields: the care of the collections, exhibition, and investigation. The space in the museum building is divided approximately into thirds among zoology, paleontology, and anthropology. In the exhibits of invertebrate and botanical paleontology, the plan is to have large exhibits, suitable for cursory observation, in the center of the halls; at one side, a series in geological sequence; and on the other side, further large exhibits showing details, restorations, and the like. In the hall of vertebrate paleontology another plan is necessary on account of the size and variety of the exhibits. The display here is deservedly popular on account of the admirable specimens, some of which are unique.

A. A. DOOLITTLE, *Recording Secretary.*

621ST MEETING

The 621st meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club at 8 p.m., February 19, 1921. Vice-President A. S. HITCHCOCK presided, and forty seven persons were present. On recommendation of the Council, Mr. O. M. FREEMAN was elected to membership.

Informal Communications

Professor E S. MORSE, former president of the Boston Society of Natural History, addressed the Society briefly. The Secretary read by title a paper by S. STILLMAN BERRY *Notes on some Japanese Cephalopods, a review of Sasaki's "Albatross" report.*

Regular Program

C. E. MCCLUNG: *Chromosomes in relation to heredity.*

Modern biological work is characterized by greater exactness of methods and by the correlation of effort in different fields. These features are particularly marked in studies on heredity in which the existence of separate or unit characters has been determined and their exact numerical distribution observed. Correspondingly, careful and minute studies of the germ cells have revealed a mechanism which supplies a full explanation for the behavior of characters in heredity. Of primary importance is the observation that the character of an organism can be fully known only when the composition of its germ cells is understood. Thus, commonly, when two white animals are bred together, it is expected that their young will be white but cases are known where the result is a progeny of strongly colored coat. Such results are now understood and may be predicted in cases where the nature of the germ cells of the parents is known The basis of all modern work in genetics was laid by an Austrian monk, Gregor Mendel, in the middle of the last century, but his results emained unknown for fifty years.

From a study of the mechanism of heredity, as revealed in the germ cells, it is found that the equivalence of the two parents is explained by their equal contribution of a substance, called chromatin, of most highly organized character As one evidence of this organization the integration into a definite number of bodies, called chromosomes, is observed in every cell in each individual of a given species. Not only is the number exact but the size, form and behavior, so that it is possible to classify some animals by their chromosomes alone. In the structure and behavior of the chromosomes we find an explanation of the alternative inheritance of contrasting characters, of the chance distribution and recombination of characters, of their transmission in groups, and of breaks in these groups. An exact analysis of the structure of the chromosomes shows them to be made up of definite units whose number, arrangement and movements supply an explanation of the most detailed genetical studies Finally it has been discovered that a particular chromosome is concerned with the determination of sex. (Author's abstract.)

The paper was illustrated by numerous lantern slides, and was discussed by Mr. T L. CASEY.

SEWALL WRIGHT. *Heredity as a factor in the resistance of guinea-pigs to tuberculosis*

The paper described some experiments which have been carried on by cooperation between the Bureau of Animal Industry and Dr. PAUL A. LEWIS of the Henry Phipps Institute of Philadelphia. The resistance to tuberculosis has been tested in about 800 guinea-pigs belonging to five closely inbred families, crosses between these families, and in a control stock which has never been inbred.

It was found that sex, age, rate of gain, and weight at inoculation made very little difference in the length of life after inoculation, determining in all less than 10 per cent of the observed variation. On the other hand, marked differences in resistance were found among the inbred families. Inbreeding itself was not a factor of great importance in increasing susceptibility although of the greatest importance in isolating different degrees of resistance. Two of the inbred families, with fifteen to twenty generations of exclusively brothersister matings back of them, were superior to the control stock, while three were inferior The crosses between the families produced young which were in general at least equal to the better of the two parental families Resistance is thus apparently dominant over susceptibility. There was equal transmission from sire and dam and to progeny of either sex. In certain crosses, the progeny were markedly superior to either parent strain, indicating that these strains were resistant for different reasons, each thus being able to supply what the other lacks. Among the crossbreds over 30 per cent of the variation in length of life was determined by the amount of blood of the best family, contrasting with less than 10 per cent determination by age, weight and rate of gain combined, and leaving something over 60 per cent determined by conditions at or following inoculation.

There was no relation between the rank of the inbred families in resistance to tuberculosis and their rank in other respects, such as average weight, fertility, and success in raising young. As in all of these cases, however, the importance of inbreeding in isolating hereditary differences was brought out by contrasting the marked differences among the inbred families and their crosses, with the lack of appreciable correlation between brothers within the random bred stock (Author's abstract.)

The paper was illustrated by diagrams and curves, showing the tendencies discussed.

A. A. DOOLITTLE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

THE PROPOSED CENTRAL ENGINEERING SOCIETY IN WASHINGTON.

The initial step toward the organization of a central engineering society in Washington was taken by the Washington Section of the American Society of Mechanical Engineers at its annual dinner on June 9. The plan, as outlined by Professor GEORGE A. WESCHLER, chairman, and A. R CHEYNEY, secretary-treasurer of the Section, suggested that a larger organization be founded upon one of the existing societies as a nucleus, to be open to all engineering and technical men in the city, and to be governed by a representative body nominated by the local sections of the various national engineering societies. This plan is similar to that of the ACADEMY and its Affiliated Societies.

Messrs. A. G. CHRISTIE and W. F. BALLINGER reported on the experience of the Baltimore and Philadelphia Engineers' Clubs, respectively. Mr. L. W. WALLACE, executive secretary of the Federated American Engineering Societies, discussed the work of that organization. Dr. R. B. SOSMAN, secretary of the ACADEMY, spoke on the experience of the ACADEMY in forming such an organization.

Informal views of the plan were also presented by the following representatives of the Washington sections of the engineering societies: JOHN C.

Hoyt, American Society of Civil Engineers; E. A. Holbrook, American Institute of Mining and Metallurgical Engineers; Milton M. Flanders, American Institute of Electrical Engineers; Harry D. Appleby, American Association of Engineers; H. C. Dickinson, Society of Automotive Engineers; William Blum, American Chemical Society; S. Tour, American Society for Steel Treating, and John S. Conway, Washington Society of Engineers. Mr. Watson Davis offered the aid of the scientific column of the *Washington Herald*, and there was informal discussion by W. H. Bixby, A. M. Holcombe, and others.

The meeting adopted a resolution endorsing the general idea of a central engineering organization and requesting the various societies interested to appoint delegates to meet at the call of the chairman of the Mechanical Engineers and draw up a detailed plan for submission to the societies.

Three societies may be considered available as a nucleus, namely, the Washington Society of Engineers, the local section of the American Association of Engineers, and the Council of the Federated American Engineering Societies. The last of the three, being a national federation, is less likely to be considered than the other two. The Washington Society of Engineers is the older organization of the remaining two, having been founded in 1905 and having at present about 500 members. The American Association of Engineers is a national organization, but is composed of individuals and not constituted by the combination of other organizations or their representatives.

Several of the speakers laid special stress upon the desirability of combining scientific, technical and engineering societies into a single federation, but no definite plan toward this end was presented.

Among the purposes of the proposed engineering organization would be the provision of a meeting place for the societies, the maintenance of a library for reference books and current periodicals, a central secretarial organization for the routine business of the societies, and the formation of committees to take an active part in civic affairs involving engineering and technical questions.

NOTES

The Washington Section of the American Society of Mechanical Engineers elected the following officers at the annual dinner on June 9: *Chairman*, L. A. Fischer, of the Bureau of Standards; *Vice-Chairman*, O. P. Hood, of the Bureau of Mines; *Secretary-Treasurer*, C. E. Oakes, of the Federal Power Commission.

The 14th National Conference on Weights and Measures was held at the Bureau of Standards on May 23–26. Among the subjects given special consideration at the meeting were: The sale of bread by weight, the detection of shortages, the weighing of coal, and the testing of pumps for measuring liquids.

The purchase of additional land near the Connecticut Avenue entrance to the National Zoological Park, provided for in the Sundry Civil Bill for 1921, has been completed. The addition to the Park is about 6 acres, making the total area about 175 acres.

The Radio Laboratory of the Bureau of Standards is cooperating with the Bureau of Markets of the Department of Agriculture in the establishment of a system of broadcasting market reports by radio. As it is likely that a

wide demand for radio equipment will develop, the Bureau has under way plans for the study of commercial apparatus and the preparation of specifications as to the behavior and usefulness of radio sets designed for general use.

The cases containing the exhibit of radium ores and radioactive minerals, prepared incidentally to the visit of Madame CURIE to Washington, have been removed from the Art Gallery of the National Museum and now form a permanent exhibit at the east end of the Mineral Hall of the Natural History Building.

Scales for the measurement of length are now being constructed directly from the fundamental wave lengths of light without the use of any intermediary standard such as the standard meter bars. For example, the Bureau of Standards has recently completed the rulings on a 6-inch standard scale for a manufacturing concern, using light waves from a neon tube as the length standard.

Dr. J. M. ALDRICH, associate curator of insects at the U. S. National Museum, left Washington in May for a two months' study of the insects, and particularly the Diptera, of central Alaska, along the line of the new Alaska Railroad between Seward and Fairbanks.

Vice-President CALVIN COOLIDGE has been elected chancellor of the Board of Regents of the Smithsonian Institution to succeed the late Chief Justice EDWARD D WHITE.

Dr F. G COTTRELL, chairman of the Division of Chemistry and Chemical Technology, National Research Council, sailed for Europe in June to make a survey of current applications of oxygen and helium in European countries He also expected to attend the meeting of the International Union of Pure and Applied Chemistry in Brussels on June 27.

Mr. S T. DANA, assistant chief of the research branch of the U. S. Forest Service, has resigned to become land agent and forest commissioner of the State of Maine, with headquarters at Augusta.

Mr. ROBERT C DUNCAN, physicist at the Bureau of Standards, has resigned to accept a position with the Bureau of Ordnance of the Navy Department.

Mr. F. C. FAIR, formerly Washington representative of the American Standardizing Bureaus, an organization having supervision of the manufacturing of pharmaceutical products for several associated companies, has become chief chemist of the Central Railway Signal Company at Hammond, Indiana.

Mr. CHARLES S. HAWES, in charge of the Bureau of Research and Statistics, War Trade Board Section, Department of State, died suddenly on Friday, April 22, 1921, in Chicago, Illinois. Mr. Hawes joined the War Trade Board in 1918 and remained with the new section when the old Board was dissolved. As head of its Bureau of Statistics he had been chiefly concerned of late with the importation of dyes, chemicals, and coal-tar products and had compiled a recently published report on dyes.

Mr. CARL L. HUBBS, curator of fishes in the Museum of Zoology, University of Michigan, has been studying the lampreys and lancelets of the National Museum collections, having been extended laboratory facilities for the purpose.

Dr. W. J. HUMPHREYS of the Weather Bureau has been elected Secretary of the American Geophysical Union, to succeed Dr. H. O. WOOD, resigned.

Mr. ENOCH KARRER has resigned from the Bureau of Standards to accept a position as physicist at the Nela Research Laboratory, Nela Park, Cleveland, Ohio.

Mr. SIDNEY D KIRKPATRICK, chemist with the U. S. Tariff Commission, has resigned to join the editorial staff of *Chemical and Metallurgical Engineering*, in New York City.

Mr. ALBERT G. LOOMIS has resigned as assistant professor of chemistry at the University of Missouri to become physical chemist at the new cryogenic laboratory of the Bureau of Mines.

Dr. WILLIAM M. MANN, assistant entomologist in the U. S. Department of Agriculture, left Washington in June to accompany an expedition to the region of La Paz, Bolivia, under the direction of Dr. H. H. RUSBY, dean of the school of pharmacy at Columbia University. The main object of the expedition, which is financed by the H. K. Mulford Company, is the collection of herbs and plants likely to be of use in medicine, but general studies will also be made of the fauna and flora.

Dr. C. L. MARLATT, assistant chief of the Bureau of Entomology, U. S. Department of Agriculture, received the honorary degree of Doctor of Science from the Kansas State Agricultural College in June.

Dr. J. C. MERRIAM, president of the Carnegie Institution of Washington, received the honorary degree of Doctor of Science from Columbia University in June.

Dr. TAKEJIRO MURAKAMI, assistant professor in the iron and steel research institute of Tohoku Imperial University, Japan, visited Washington in June.

Mr. A DE C. SOWERBY visited the scientific institutions of Washington in June, on his way to South China, where he will spend three years in an extensive biological survey, with particular attention to the higher vertebrates.

Dr. C. G. STORM has been transferred from the position of professor of chemical engineering at the Ordnance School of Application, Aberdeen Proving Grounds, Maryland, to the office of the Manufacturing Service of the Ordnance Department in Washington.

Dr. ALEXANDER WETMORE, of the Biological Survey, U. S Department of Agriculture, has returned from a year's collecting trip in Argentina. He made a special study of the migratory shore birds.

Dr. H. O. WOOD, formerly assistant secretary of the National Research Council, has been appointed a research associate of the Carnegie Institution of Washington, and is in California engaged in a reconnaissance of the southern California seismological field, under the general supervision of an advisory committee in seismology appointed by the Institution.

Mr. HARPER F. ZOLLER, formerly chemist with the Dairy Division Research Laboratory, U. S. Department of Agriculture, is at present bacteriological chemist for the Nizer Laboratories Company, manufacturers of food products at Detroit, Michigan.

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PHYSIOLOGICAL CHEMISTRY.—*Chemical structure and physiological action.*[1] C. L. ALSBERG, Bureau of Chemistry.

The subject matter which I propose to present to you tonight contains nothing essentially new to the pharmacologist. It deals, however, with a field of research that, while of the greatest importance to the welfare of mankind, is still very much in flux. However, a subject in flux is more interesting than one that is in a static state with all phenomena accurately ticketed and labeled. It still permits the exercise of the imagination. Hence what I have to offer to you tonight must be, in the main, a series of speculations and of observations none too well coordinated. Only a part of it has found its way into the general text-books, and this is my excuse for the selection of my subject.[2]

Paracelsus wrote many centuries ago, "The real object of chemistry is not to make gold, but to prepare medicine." Schmiedeberg has defined the aim of the science of pharmacology as the production of physiological reactions with chemical reagents. The pharmacologist hopes, therefore, to contribute toward the solution of some of the problems of biology by using chemical stimuli as the physiologist uses physical ones. Some pharmacologists have believed that the reaction of living things to chemical stimuli is necessarily the result of a chemical reaction between the stimulating chemical and some substance in the cell stimulated. The hope has been expressed that eventually it will be possible to write the equations for these reactions as for any other chemical reaction. However, this hope is very very far from realization, and perhaps never will be realized because, as we shall see, it represents far too simple a conception of the matter. Indeed, almost the only case that occurs to me in which it is possible

[1] Address of the retiring President of the Washington Academy of Sciences. Presented at a joint meeting of the Academy and the Chemical Society on January 20, 1921. Received July 20, 1921.

[2] L. SPIEGEL. *Chemical constitution and physiological action.* Translated, with additions, from the German, by C. LUEDEKING and A. C. BOYLSTON (D. Van Nostrand Co., New York, 1915).

to write such a reaction is carbon monoxide poisoning. In this intoxication the carbon monoxide gas unites in fixed proportions with the hemoglobin of the blood to form a very stable combination which is incapable of transporting oxygen from the lungs to the tissues. The result is asphyxiation, but even in this case we are not helped much by our ability to write this equation, for it tells us nothing about the processes that take place during asphyxia Indeed, we know very little about them. Carbon monoxide is the cause of death. The more immediate cause, however, is oxygen starvation, and if we are very exacting, we must demand the equations of asphyxia. These, however, we are quite unable to give.

Of recent years very different conceptions have been developed The older men, dominated by the imagery of organic chemistry, sought the chemical reactions underlying the phenomena of pharmacological action, thinking that they are ordinary stoichiometric reactions, very complex ones if you will, but still of the ordinary type and, therefore, dependent upon the chemical properties of the substances taking part in them. In those days the prevailing conception of protoplasm was that it consisted of huge, very complex, very unstable molecules The various parts of such a live molecule were believed to have different functions According to this conception, the live molecule might have been pictured as resembling a chestnut burr bristling with prickles or grappling hooks each capable of grappling a specific and different food substance.[3] Some of the poisons were supposed to be anchored by such grappling hooks just like foodstuffs and the specific action of a given substance upon a given cell or tissue was supposed to be due to the fact that that substance had some inherent property that caused it to be anchored by some specific grappling hook in that cell Therefore, explanation of the physiological action of a substance was sought primarily in the structure of its molecules rather than in its physical properties To some particular grouping of the atoms in the molecule solely was attributed the physiological action of the substance [4] Such a group was spoken of as the carrier of the action, and much was written about "toxophore" groups,

[3] P EHRLICH *On immunity with special reference to cell life* Croonian Lecture Proc Roy. Soc London 66 432–437, 446

[4] O LOEW *Ein natürliches System der Giftwirkungen* (Stuttgart, 1893) P EHRLICH *Ueber die Beziehungen von chemischer Constitution und pharmakologischer Wirkung* Vortrag gehalten im Verein fur Innere Medicin am 12 December, 1898 v. Leyden Festschrift p. 647 (August Hirschwald, Berlin, 1902)

"anaesthetic" groups, "narcotic" groups, "tetanic" groups, and the like.

Our present-day conception of protoplasm is different. We no longer think of a giant living molecule so unstable that its decomposition and continuous reconstruction constitute the phenomena of life We no longer consider protoplasm as homogeneous We believe it to be heterogeneous, to consist of a series of phases, an emulsion, a series of fine droplets and particles in suspension.[5] According to the laws of surfaces, which I shall have to ask you to take for granted tonight, as we have no time to consider them now, some substances will concentrate at surfaces and this concentration will be greater the greater the curvature of the surface [6] Therefore, in such a system as an emulsion you have membranes formed automatically at all surfaces, and so it seems to be with protoplasm You must conceive of these as chemical membranes, as mere surface layers, not necessarily visible under the microscope, representing the very great concentration at the surface of a droplet of one or more of the substances dissolved in the droplet or in the surrounding medium Each droplet is then a sort of test tube shut off to a certain degree from the other droplets and from the liquid in which it is suspended Phenomena can therefore go on in such a droplet without affecting the other droplets except indirectly Such a conception of protoplasm very greatly simplifies, as we shall see later, our conception of the physiological action of chemical substances since instead of being a purely chemical concept it is physical as well as chemical. It leaves room for such considerations as the surface effect of the substance, its solubility in the membrane, in the droplet, in the various phases of a gel, etc , etc.

With the old conception of protoplasm as a homogeneous chemical entity the physiological action of a substance was referred merely to its chemical character and reactivity. This point of view impeded rather than aided progress With the acceptance of the idea of protoplasm as a physical system, rather than as a chemical structure, the conviction has gained ground that the physiological action of a substance depends not merely upon its chemical structure but also upon its physical properties, or rather those properties[7] that lie on the frontier between physics and chemistry, such properties as solubility, diffusi-

[5] C. L ALSBERG *Mechanisms of cell activity* Science N S **34**: 97 105 July 28, 1911

[6] W M BAYLISS *An introduction to general physiology* (Longmans, Green & Co, London, 1919) Chap I.

[7] G. GIEMSA *Neuere Ergebnisse der Chemotherapie* Archiv Pharm **257**: 194 1919.

bility, dissociation, colloidal state, electrical charge and the like. Of course, in the last analysis the physical state is but an expression of the chemical constitution and vice versa, but these are problems for the chemist, not the pharmacologist

However, I do not mean to be understood as stating that chemical constitution has nothing to do with physiological action. I mean merely that very frequently changes in constitution produce changes in action chiefly because they influence the physical properties of the substance rather than its power of reacting chemically with other substances Certainly very slight changes in constitution often produce very great changes in physiological action You all know that stereo-isomerism influences the taste of simple amino acids, some being sweet, some bitter;[8] that one form of asparagin is sweet while the enantiomorphous form is tasteless; that l-adrenalin causes the smaller arteries to contract greatly while d-adrenalin is far less active.[9] The examples might be multiplied almost indefinitely Indeed, as we shall see later, substances of a very widely different chemical structure may have a very similar action Of these we may be sure that their action depends rather upon their physical than their chemical properties

What I have to say tonight will deal as much with physical or physico-chemical properties as with chemical constitution Moreover, I do not propose to deal with many simple inorganic substances like arsenic, iodine or phosphorus The physiological action of many of the elements seems to be an intrinsic property as much as their atomic weight. Indeed, within the same group of the periodic system the toxicity of kations, with certain exceptions, increases with the increase of the atomic weight.[10] Until we know far more than we do now concerning the underlying causes for the physical properties of the elements we are not likely to know why, for example, iron is less poisonous than cobalt It is much the same question as why bromine is red and chlorine green We do know, however, that elements like arsenic, phosphorus and nitrogen, which exhibit variable valence, may be toxic and we suspect that their action is probably in some way connected with their change from one state of valence to another. We also know that in some way the toxic action of kations and anions is

[8] F. OERTLY and R G MYERS *A new theory relating constitution to taste* Journ Amer Chem Soc 41: 861 1919

[9] W H SCHULTZ *Quantitative pharmacological studies Adrenalin and adrenalin-like bodies* Hygienic Lab Bull 55, U S Public Health and Marine Hospital Service, 1909

[10] BLAKE Compt rend 1839, Proc Roy Soc London 1841 Amer Journ Sci 1874; Ber deutsch Chem Ges 14 394 1881

related to their effects upon colloids, especially proteins;[11] but here again the power of kations to precipitate proteins and of anions to produce the reverse effect is, so far as our knowledge at present goes, an intrinsic property. Since it is, speculation upon these phenomena is rather fruitless till the physicists have gone a great deal further. I shall deal tonight therefore in the main with substances more complex than the simple elements

There are in the main three general ways in which a substance may affect a cell:

The substance may attack the surface of the cell.

The substance may affect the cell indirectly without entering it

The substance may affect the cell in the course of entering, or after entrance into the cell.

Many substances destroy the surface layer of a cell by precipitating or coagulating it. This is the effect of many astringents, such as the salts of many heavy metals, ferric chloride for example, when in sufficient concentration Other substances dissolve some of the constituents of the surface layer as, for example, ether when in sufficient concentration.[12] Other substances combine with some component of the surface layer. This may be the action of saponins.[13]

Substances which neither enter cells nor attack the cell surface act chiefly by affecting the concentrations within the cell They either withdraw water from the cell so that it tends to shrivel and become desiccated, or they cause water to penetrate into the cell so that it swells These processes are called plasmolysis because they may, if carried to extremes, cause the protoplasm to disintegrate Those among you who are botanists or physiologists know that this phenomenon may be studied by observing the behavior of suitable plant cells or red blood corpuscles when placed in solutions of the substances to be tested. In many plant tissues the protoplasm forms a layer lining a rigid cellulose wall It is really a sac enclosing a relatively large space filled with sap. When such a cell shrinks or is plasmolyzed the protoplasm withdraws from the cellulosic cell wall and this can be seen very easily under the microscope In the case of red blood corpuscles, these become crenated, that is, they shrink and take on the

[11] BAYLISS, op cit, p 35

[12] L. HERMANN *Ueber die Wirkungsweise einer Gruppe von Giften* Arch Anat Physiol. u Wiss Med 1866: 27

[13] H E WOODWARD and C L ALSBERG *A comparison of the effect of certain saponins on the surface tension of water with their hemolytic power* Journ Pharm Exp Therap 16: 237 1920

appearance of a globe studded with projections like the head of a crusader's mace.

That a substance may plasmolyze a cell it is obvious that it must fulfill certain conditions. It must exert osmotic pressure; it must not be able to penetrate into the cell, or if it does, it must do so very slowly, that is, more slowly than water, for if it passes quickly into the cell the osmotic pressure within and without will be very quickly equalized and there will be no plasmolysis In other words, the cell-membrane must be semi-permeable to the plasmolyzing substance. A semi-permeable membrane is one that permits only certain dissolved substances to pass through it Now most cell-membranes are semi-permeable to most salts of organic as well as inorganic bases, to the sugars and to many other substances They do not permit these substances to pass through readily. When brought into solutions of such substances, cells may be plasmolyzed. One group of organisms seems to form an exception. A large number of bacteria do not seem to be surrounded with membranes semi-permeable in this sense, salts pass into them apparently unhindered. They all can be stained according to the method of Gram, and are known as the Gram positive bacteria. They cannot be plasmolyzed

Considerations of this sort help us to understand the action of certain salts and other substances upon the intestines You all know that Glauber's salt (sodium sulfate) and Epsom salt (magnesium sulfate) are laxatives Now one of the characteristics that distinguish such salts from others, say sodium chloride, is that they are not readily absorbed through the intestinal wall. Not being absorbed readily they cause the osmotic pressure of the intestinal contents to remain great as the food passes down the alimentary canal. In order to withdraw water from the intestinal contents the intestines would have to do an amount of osmotic work which would be very great indeed. The result is that water remains in the intestinal contents or is secreted into it so that the contents remain bulky and peristalsis is stimulated This is one of the main factors, though not the only factor, in the purgative action of these salts It is a physical factor dependent upon the slow absorption of these salts through colloid membranes, rather than upon any strictly chemical reaction dependent upon the structure of the molecule or its chemical reactivity.

We have seen that the phenomenon of plasmolysis furnishes a method to tell what substances do not enter cells Conversely we can tell what substances do pass readily into cells, for such substances will not

plasmolyze A study of the plasmolyzing power of many hundreds of substances has shown that substances of the most diverse chemical character can enter cells readily. They have neither molecules of similar size, nor similar melting points nor similar boiling points, nor similar chemical affinities. They have one property in common; they are more freely soluble in fatty oils and lipoids than in water. If any of these substances be mixed with water and oil, much of the substance will dissolve in the oil and relatively little in the water. As the physicist would put it, the distribution coefficient for these substances between oil and water is greatly in favor of oil [14]

A very good illustration of this phenomenon is furnished by glycerin and its derivatives, mono- and dichlorhydrin.[15] Glycerin enters cells very slowly, monochlorhydrin quite rapidly and dichlorhydrin almost instantaneously. Glycerin has no narcotic action, monochlorhydrin has a fairly strong narcotic action and dichlorhydrin quite a powerful narcotic action. In the days of the purely chemical conception of protoplasm, it would have been assumed that chlorine was a "toxophore" group,[16] that perhaps its action depended upon its electronegative character or that mono- and dichlorhydrin had greater affinity for the cell-substance The fact is that glycerin is but slightly soluble in oil and very soluble in water while its chlorine derivatives are very much more soluble in oils than in water [17]

Since so many substances that pass readily through the semi-permeable cell membranes are oil-soluble, many biologists have concluded that the cell membrane is, in part at any rate, composed of fat-like substances, probably lipoids, like lecithin and cholesterin This inference is based on the fact that it has been shown for a great variety of semi-permeable membranes that they permit only those substances to pass through them that are soluble in them. Thus chloroform, but not alcohol, may be made to pass through rubber membranes Hence it was inferred that since only fat-soluble substances pass readily through the semi-permeable membranes of cells, these membranes must consist, in part at any rate, of fats or fat-like substances such as

[14] E. OVERTON *Studien ueber die Narkose* (Jena, 1901) H MEYER Arch exp. Path Pharm **42:** 109 1899, **46:** 338 1901. P EHRLICH Therap Monatsh, March, 1887

[15] E OVERTON *Ueber die allgemeine osmotische Eigenschaften der Zelle* Vierteljahrb Naturforscherges Zurich **44:** 880 1899

[16] C R MARSHALL and H L HEATH *The pharmacology of the chlorhydrins, a contribution to the study of the relations between chemical constitution and pharmacological action* Journ Physiol **22:** 1, 2 1897

[17] H KIONKA *Zur Theorie der Narkose* Arch Int Pharmacodynamie et Therapie **7.**

the lipoids and cholesterin This is the more probable as lecithin and cholesterin have but slight surface tension effect and would therefore tend to accumulate at surfaces[18] Indeed it is probable that all substances that lower surface tension must tend to accumulate at surfaces and take part, to a greater or lesser degree, in the formation of such membranes whether such substances come from within the cell or from the liquids that bathe the cell.

This hypothesis of the semi-permeability and lipoid character of the cell-membrane has not been accepted universally. Czapek,[19] for example, believes that the ability of substances to pass through the cell-membrane is a function of their ability to affect surface tension rather than a function of their oil solubility. However, substances that lower surface tension seem also to be oil-soluble Perhaps the two traits are but expressions of the same underlying physical property. Shryver[20] believes the semi-permeability to be dependent upon the presence of a gel in the membrane. However, all the theories explaining the semi-permeability of cell-membranes that have been advanced of recent years are based upon physical or physico-chemical considerations. Not one assumes any dependence upon molecular structure or chemical reaction. That is the important point for us this evening.

We see then that the factors that determine the power of substances to enter cells are physical properties rather than molecular structure or chemical reactivity If we examine the action substances exhibit after they have obtained entrance into cells, we find that an immense number of substances cause narcosis. In the lower organisms protoplasmic streaming and other forms of motion cease In the higher organisms endowed with a nervous system, this undergoes a more or less complete paralysis The most diverse substances have this effect —Pentane, chloroform, ether, alcohol, phenanthrene, salicylamid monacetin They have no common chemical properties except that they are neither acids nor bases They are spoken of as the "indifferent narcotics" to distinguish them from the narcotic alkaloids which are bases We have here again a common physiological action de-

[18] It should, however, be noted that many food substances, for example glucose, cause plasmolysis, yet they must enter cells for otherwise they could not nourish them There are undoubtedly other factors that enter into the structure of cell membranes and a number of theories on the subject have been advanced

[19] F Czapek *Ueber die Oberflächen-spannung und den Lipoidgehalt der Plasmahaut in den lebenden Pflanzenzellen* Ber deutsch botan Ges **28**: 480 1910

[20] S B Shryver *Investigations dealing with the phenomena of "clot" formations, Part II* Proc Roy Soc **B 87**: 366 1914

pendent apparently upon a common physical property exhibited by substances of the most diverse chemical structure [21]

That this relation is not accidental is proven by the fact that the narcotic power of these substances is broadly proportional to their relative solubility in oil as compared with their solubility in water; that is, proportional to their distribution coefficient between these two solvents. The more this ratio is in favor of oil the more narcotic the substance. This was proved for a large number of substances, both by H Meyer[22] and by Overton[23] who experimented with tadpoles. These animals were placed in water containing varying concentrations of the substance to be tested and the effect noted In this way the lowest concentration capable of narcotizing the tadpoles was determined. Comparison of the minimum narcotic concentration thus determined for a large number of substances demonstrated that these concentrations show a direct parallelism with the distribution coefficients of the respective narcotics between oil and water

This parallelism of the effective narcotic strength of a substance with its oil-water distribution coefficient is demonstrated strikingly if experiments be made, as was done by Meyer[24] with the same substances at different temperatures. The narcotic power of each substance changes with the temperature in proportion to the shift made by the temperature in the oil-water distribution coefficient This is especially striking in the case of chloral as will appear from an examination of table 1 which has been adapted from Meyer's publication on this subject.

It is obvious that experiments analogous to Overton's tadpole experiments can be performed upon animals breathing through lungs instead of gills only with volatile narcotics like ether or chloroform The non-volatile narcotics cannot be tested in any direct way because when given by the mouth the rate of absorption from the alimentary tract may vary in different individuals and in the same individual at different times. Moreover the rate varies with the solubility of the narcotic in the contents of the intestinal tract. Thus phenanthrene is not sufficiently soluble in water to be absorbed and exert any action though it has actually narcotic power. Long ago Bert showed that

[21] L HERMANN, op cit

[22] H MEYER, op cit

[23] E OVERTON, op cit.

[24] H MEYER, *Zur Theorie der Alkohol Narkose* III Mittheilung *Der Einfluss wechselnder Temperatur auf Wirkungstärke und Theilungs-Coefficient der Narcotica* Arch. exp Path u Pharmakol **46:** 338 1901

narcosis through the inhalation of air containing vapors of narcotics did not take place however long such a mixture was breathed unless the vapor pressure of the narcotic was above a definite threshold value.[25] The narcosis-producing vapor pressures run parallel in a general way with the oil-water distribution coefficients of the different

TABLE 1.—THE RELATION OF THE POWER OF CERTAIN SUBSTANCES TO NARCOTIZE TADPOLES AT DIFFERENT TEMPERATURES, TO THE DISTRIBUTION COEFFICIENTS OF THESE SUBSTANCES BETWEEN WATER AND OIL AT THESE TEMPERATURES

Distribution coefficient	Threshold narcotic value in normal solution	Substance
0 026	1/3	Alcohol at 3° C
0 047	1/7	Alcohol at 36° C
0 053	1/50	Chloral at 3° C
0 066	1/70	Monacetin at 36° C
0 093	1/90	Monacetin at 3° C
0 236	1/250	Chloral at 30° C
0 437	1/200	Benzamid at 36° C
0 672	1/500	Benzamid at 3° C
14 000	1/600	Salicylamid at 36° C
22 230	1/1300	Salicylamid at 30° C.

volatile narcotics[26] It is moreover curious to note that the effective vapor tension of the narcotic in the blood of the narcotized animal is of the same general order of magnitude, if calculated for the same body temperature, in the animal series from the frog to the dog[27]

Meyer and Overton assumed that since the narcotics are especially soluble in the lipoids they will, of necessity, accumulate in those parts of the body that are richest in lipoids The nervous system is peculiarly rich in lipoids. Hence these investigators explained in this manner the accumulation of the lipoids in the nervous system and their selective action upon it[28] However, just as the lipoid theory of semi-per-

[25] P BERT *Sur la mort par l'action des mélanges d'air et de vapeurs de chloroform* Compt rend Soc Biol 35: 241 1883

Méthode d'anaesthésie par les mélanges doses d'air et de vapeurs de chloroform Ibid 409 *Sur l'anaesthesie par l'ether* Ibid 522

[26] E OVERTON, op cit p 85

[27] H WINTERSTEIN *Die Narkose* (Julius Springer, Berlin, 1919), p 33

[28] Meyer and also Overton believed that the indifferent narcotics accumulated most in the cortex because, according to the older analyses of the brain, the cortex is richest in lipoids Bethe, however, pointed out that, according to more recent analyses of Thudichum, Koch and others, the white matter is far richer in lipoids than the gray, and Bethe dwelt upon this as one of the objections to this hypothesis However, there is no good reason to suppose that interruption of the association tracts is not capable of producing narcosis as readily as direct action on the cortical cells themselves

meability has not been generally accepted, so the Overton-Meyer lipoid theory of narcosis is not accepted universally Traube believes surface tension effect and not lipoid solubility is the main factor and others believe that adsorption of the narcotic by the nerve cell is the main factor.[29] This is not the place to discuss these hypotheses other than to point out that none of them considers the chemical structure of the narcotic molecule as of moment except in so far as the chemical structure of the molecule determines its physical properties

We may therefore fairly assume that in the case of the indifferent narcotics we have an apparently specific action upon a specific organ, the nervous system, dependent quite as much upon the physical properties of the narcotic as upon its chemical structure. The older pharmacologists would have said that the narcotic acts upon the nervous system specifically because the nerve cell or the nerve cell protoplasm contains a specific chemical group which has a special affinity for the narcotic and combines or reacts with it

Now these theories of narcosis explain why the nervous system attracts the narcotic, in other words, they give a simple physical explanation for the distribution of the narcotic within the body. They do not tell us in the least what the narcotic does after it accumulates in the cells. Concerning the nature of the action of the narcotic after it has accumulated within a cell a number of theories have been advanced. We have not yet enough experimental data to reach a decision and there is hardly time tonight for a full discussion of them. However it will be of interest to indicate the general character of some of them.—if protoplasm is essentially an emulsion or gel, one of the phases of which is oil-like, then the solution of the narcotic in the oil phase must greatly affect the character of this phase and its surface phenomena.[30] There will inevitably be a tendency to change the permeability of the membranes at the interfaces with a tendency to the redistribution of the protoplasmic components to conform to new conditions. The tendency must be to change the composition of the phases relatively. If the narcotic enters into adsorption combinations with components of the cell this too must alter the relative composition of the phases. If the adsorption be upon enzyme molecules the functioning of the cell would be disturbed correspondingly.[31] In either event, whether the narcotic dissolves in the oil

[29] H WINTERSTEIN, op cit

[30] H MEYER *Zur Theorie der Alkohol-narkose* I Mittheilung Arch. exp Path u. Pharmakol 42: 112 1899

[31] H WINTERSTEIN, op. cit p 276, ff

phase or forms a blanketing adsorption layer about enzyme molecules, or does both, the effect must be to hasten certain normal processes and retard others It is a well-established fact that many narcotics retard *extra corpore* many enzyme reactions, especially oxidations. It is also well established that in narcotized cells the oxidation metabolism, that is, respiration, is dampened That the presence of narcotics also tends to hasten some protoplasmic processes is evident from the effect of such substances on the rate of autolysis, that is, the self-digestion of cells Even small quantities of such substances as chloroform or toluol very rapidly hasten the onset of the autolysis of cells *in vitro*.[32] Apparently they hasten it because through lipoid solubility, surface tension effect, or adsorption, they disturb the balance of the protoplasmic phases with a resulting destruction of the coordinating mechanisms of protoplasm.[33] The intracellular enzymes then run riot and rapid autolysis results Perhaps physical phenomena, similar in kind if not in degree, are involved in narcosis. Certainly in chloroform narcosis katabolism is increased. It is conceivable that in the manner above suggested a substance may exercise a profound effect upon a cell without necessarily entering into a chemical union with some constituent of the cell. That such a chemical union must of necessity precede the attack of a poison upon a cell was formerly very generally assumed

In discussing phenomena of this character we must beware lest we generalize too widely No one hypothesis is applicable to all cases Thus there are cases in which it is perfectly well known that substances accumulate in cells because they combine chemically with some constituent of the cell The alkaloids furnish an example. Tannic acid precipitates many alkaloids Some algae contain tannic acid and when they are brought into solutions of the free alkaloids, the base,

[32] v. Schroeder long ago showed that the autolysis of yeast went on more rapidly in the presence of a little ether than without Evidently ether does to yeast cells exactly what it does to red blood corpuscles, it lakes them, *i e*, it dissolves the lipoids of the cell-membranes making the latter permeable to intra-cellular substances, among them the enzymes It seems that a process similar to hemolysis, called cytolysis, may occur in any cell Probably this phenomenon underlies such pathological conditions as acute yellow atrophy of the liver which is characterized by an *ante-mortem* autolysis of the liver and perhaps other organs It is quite conceivable that a toxic substance absorbed from the gut may lake or cytolize the liver cells destroying the coordination between their own ferments and setting these ferments free to work their own cells' destruction It is significant that yellow phosphorus, chloroform and chloral hydrate, all lipoid-soluble substances, are capable, when taken by the mouth, of producing a pathological condition bearing considerable resemblance to acute yellow atrophy of the liver

[33] C L. Alsberg *Mechanisms of cell activity.* Op. cit.

which penetrates into the cells, is precipitated by the tannic acid The formation of these precipitates may be observed under the microscope The alkaloid being removed by precipitation, more alkaloid diffuses in until all the available tannic acid has been consumed The alkaloid enters because the cell-membrane is permeable to it Whether this permeability is due to lipoid solubility of the alkaloid, surface effect, or adsorption need not concern us now. Were there no tannin within the cell, only so much alkaloid would diffuse into it as is required to establish equilibrium between the interior of the cell and the medium bathing the cell More, however, passes in because a part is combined firmly with the tannin. By such a chemical mechanism, as well as in the other ways above discussed, substances may accumulate in special organs or cells.[34]

The indifferent narcotics are substances that are not dissociated. The majority of the substances which readily permeate cells are not ionized. This is beautifully illustrated by the difference in the action of the free alkaloid bases and their salts, as shown by Overton. The former are more poisonous than the latter, at least to the individual cell. The free base alone is able to pass through the cell-membrane In a solution of the base all of it is free to pass through the membrane The solution of the salt only contains free base to the extent that the salt is dissociated With a base as weak as the alkaloids united with the common very powerful acids, the amount of dissociation will be very slight. The action of the salt is therefore slower than that of the free base.

Analogous conditions seem to prevail in the case of inorganic salts. As a rule ions do not pass through cell-membrane and it is very doubtful whether the ordinary salts of the organism, most of which plasmolyze, enter cells as ions[35] Certain inorganic salts, however,

[34] For other mechanisms, see W SCHULEMANN, *Die vitale Farbung in ihrer Bedeutung für Anatomie, Physiologie, Pathologie und Pharmakologie* Biochem Zeitschr 80: 1, 1917

[35] Apparently the fact that the lipoids, as shown by Thudichum, readily form colloidal solutions in water, has been overlooked by those who have speculated on the subject Koch has shown that such solutions change the solubility of inorganic salts and render them soluble with the lipoid in ether I myself have observed that if a solution of egg yolk in 10 per cent NaCl be extracted with ether a small amount of material giving the biuret reaction passes into the ether A thorough study of the manner in which lipoids and proteins modify the solubility of such substances as glucose, amino-acids, and inorganic salts is needed It may well be that it will furnish the key to the mechanism by which such food-stuffs enter cells However, it should also be kept in mind that none of the hypotheses concerning the character of cell-membranes is capable of explaining completely the entrance into cells of all substances that undoubtedly get into them I have been careful to

probably enter cells because they are more or less lipoid-soluble, for example, mercuric chloride, cadmium chloride and copper chloride. Perhaps for that reason they are so very toxic and antiseptic.

Perhaps the best summing up of the relative importance of chemical and physical factors in determining the action of toxic agents has been given by Barger and Dale in one of their papers upon the active principles of the ergot of rye: "but it by no means follows that the peculiar distribution of the action of nicotine or of the sympatho-mimetic amines depends on the existence of specific chemical receptors in the cells primarily sensitive to them, as supposed by Langley. Stimulation may be a chemical process but the fact that certain cells are preferentially stimulated by a certain group of substances such as our amines may mean that in those cells these substances readily reach the site of action, a supposition which is in accord with the view advanced by Straub ".. "On the whole then the least unsatisfactory view in the present state of knowledge seems to us to be that which regards the existence of stimulant activities as dependent on the possession of some chemical property, the distribution, and, in the main, the intensity of the activity as due to a physical property."[36]

This thought will help us to understand the reasoning that is used in the production of synthetic drugs, that is, the science known as chemo-therapy. Chemo-therapy is the name given to that phase of pharmacology which deals with the production of drugs for special and specific purposes. Sometimes its aim is defined more narrowly as the search for chemical agents that will cure infectious diseases, that is, agents that will act as internal disinfectants for the diseased body. Since such substances are usually more or less poisonous for the body cells as well as for the parasite, much of chemo-therapeutic research aims to so modify the molecular structure of the toxic substance as to render it appreciably more toxic to the parasite than to the body cells of the host.[37]

We can then divide the aims of investigators in the field of chemo-therapy into two groups, those that endeavor to influence the physical properties of drugs and therefore their intensity and place of action in the organisms, and those that endeavor to influence the chemical

attribute to the lipoid only a part of the observed phenomena. Schulemann, for example, attributes a large rôle to phagocytosis, a phenomenon undoubtedly largely dependent upon surface tension effects.

[36] Cf. also W. SCHULEMANN, op. cit.

[37] G. GIEMSA, op. cit. p. 190–191.

properties of drugs and their specific manner of action [38]

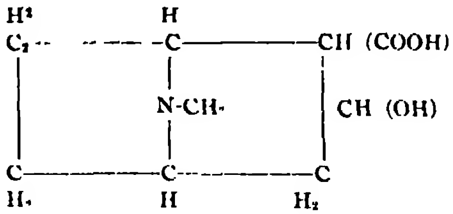
As no sharp line can be drawn between chemistry and physics so these aims of the synthetic chemist in the field of chemo-therapy can not be separated sharply. The attainment of one aim is very apt to bring the other in its train. Thus the rate of action of a drug may be accelerated or retarded by merely changing its solubility. The more soluble it is the more rapidly may it be absorbed and the more intense will be its action, since, obviously, the more rapidly it floods the body the more toxic will it be At the same time its action is likely to be more evanescent because just as it will be more rapidly absorbed so it is apt to be more rapidly eliminated The less soluble it is the more slowly will it be absorbed and the milder and more continuous is apt to be its action Moreover, at the same time, changing its solubility may change the site of action of a drug as when it is rendered insoluble in the stomach but soluble in the intestines Such an example is the tannate of an alkaloid These tannates are insoluble in the stomach, but soluble in the intestines Therefore not merely is their rate of action modified but the action itself may not begin until the drug reaches the intestines The rate, the intensity, as well as the site of action have been modified by the mere change in solubility.

Similar changes in the action of drugs can be brought about by making derivatives that are inactive in themselves but are decomposed somewhere in the body setting the active principle free By such means it is possible to retard the rate and also to change the site of action Salol, a condensation product of phenol and salicylic acid, is a good example of this sort It passes through the acid stomach but is esterified in the alkaline intestines with the gradual liberation of its component drugs Thus they act slowly and less intensely, exerting local antiseptic action in the intestines and, after gradual absorption, continuous systemic action A similar result is accomplished in the administration of inorganic substances if converted into un-ionized organic compounds Such compounds may reach the tissues before they are decomposed, exerting their action at the site of decomposition Salvarsan and its congeners are examples of this kind They are organic compounds of arsenic which are but slowly decomposed within the tissues. By their use it is possible to keep the body continuously under the influence of arsenic without serious toxic symptoms. No doubt a part of the value of salvarsan is due to the

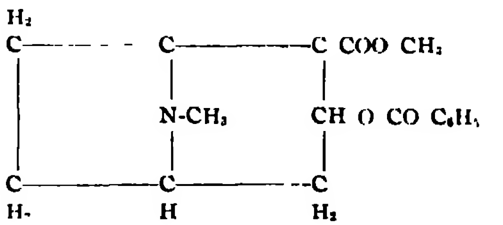
[38] S FRAENKEL *Die Arzneimittelsynthese auf Grundlage der Beziehungen zwischen chemischen Aufbau und Wirkung.* (J Springer, Berlin, 1912)

fact that it is retained in the system a long time and but slowly decomposed In a very similar manner it is possible to make an element's action milder, more continuous and free from local irritant action. Iodoform is a case in point Its action is that of iodine; but iodine itself is too powerful for local application to wound surfaces. Iodoform is slowly decomposed on wound surfaces subjecting them to the mild continuous action of iodine so that there is little local irritation

Except for salvarsan, the cases just given are examples in which the modification of the action of the drug was in the main designed to accomplish a modification of the intensity and site of action of a well-known drug substance rather than to modify its specific action or to create a new drug with a modified specific or even a totally new physiological action The investigations and the line of reasoning which lead up to the production of the valuable local anesthetic, novocaine, are perhaps typical of the latter form of chemo-therapeutic research The object of these investigations was to develop a drug with the local anaesthetic action of cocaine but devoid of its objectionable toxic effects Ecgonine, the mother substance of cocaine, has the following formula.



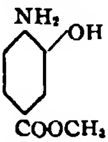
Einhorn[39] discovered that if he esterified the carboxyl (COOH) group of ecgonine with a methyl (CH_3) group and the hydroxyl (OH) group with a benzoyl group (CO C_6H_5) he obtained the very anaesthetic natural base cocaine



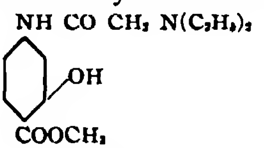
This led him to make a large number of benzoyl esters, many of which

[39] A EINHORN *Ueber neue Arzneimittel*, Ann d Chemie 371 125. 1909

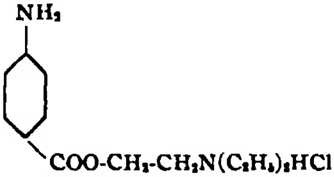
were anaesthetic. Indeed Filehne[40] concluded that the benzoyl group was responsible for the anaesthetic action. The action may be lacking if there are interfering groups such as the carboxyl (COOH) group of ecgonine Moreover it was found that when, as in cocaine, the benzoyl group was combined with a nitrogen-containing nucleus its action became most apparent. Thereupon a large series of nitrogen-containing nuclei were benzoylated and it was found that so complex a nitrogenous nucleus as that of cocaine was not necessary Many of these benzoyl esters derived from quite simple nitrogen-containing nuclei were found to have anaesthetic action. The first very simple substance of this type to find a practical use was orthoform, which is the methyl ester of para-amino-meta-oxybenzoic acid.



The objection to this compound is that it is too insoluble while its salts are too irritant It was therefore necessary to make soluble derivatives This was done by combining it with glycocoll (amino-acetic acid) derivatives. Thus there was produced a substance which has been used practically, nirvanin, the methyl ester of di-ethyl-amine-acetyl-para-amino-ortho-oxy-benzoic acid.



Further investigation showed that still greater simplification was possible by the elimination of the hydroxyl group. This led to the development of procaine, known by the trade name of novocaine, the soluble hydrochloride of para-amino benzoic acid di-ethyl-amino-ethyl ester or para-amino-benzoyl-di-ethyl-amino ethanol



This is quite a simple substance as compared with cocaine and easily made synthetically. Another simplification is the removal of the

[40] W FILEHNE *Die local anaesthesirende Wirkung von Benzoylderivaten* Berliner klin Wochenschr **24** 107 Feb 14, 1887

amino (NH_2) group from the ring as in stovaine and alypine.

However, the power to anaesthetize the sensory nerve endings is not limited to basic substances like those above described. Many substances quite unrelated to them possess this power to a greater or less degree, such as antipyrine, certain inorganic salts, quinoline derivatives, phenolic and aromatic side-chain alcohols.[41] Some of the latter, like benzyl alcohol, phenethylol, benzoyl carbinol and saligenin, promise to compete with substances of the procaine type.

That so many substances of such varying molecular configuration exhibit similar physiological action arouses the suspicion that, as in the case of the indifferent narcotics, some as yet unrecognized common physical property is concerned in their action. Significant in this connection is the fact that Schleich modified the method of terminal anaesthesia by showing that if hypotonic solutions, that is, solutions of a lesser osmotic concentration than the blood, be injected under pressure until the tissues become rigid, the concentration of the anaesthetic necessary to prove effective is reduced Now either hypotonic or hypertonic inorganic salt solutions tend to produce local anaesthesia by themselves, perhaps through merely causing swelling or shrinking of the cells, that is partial plasmolysis [42] It is also significant as bearing on the possibility of some common physical property of the local anaesthetics that Gros[43] presents evidence that bases like cocaine and procaine are made more active if set free by sodium bicarbonate from their salts, presumably because they, like other alkaloids, enter cells most readily as the free base [44]

The type of reasoning and experimentation which made a new era in surgery possible through the development of such substances as procaine is not limited to the production of new and valuable drugs. It has been applied with success to the production of new perfumes, of new antiseptics[45] and new flavoring materials

As an example of the application of this manner of reasoning in the production of flavoring substances may be cited the work of E K. Nelson in the Bureau of Chemistry upon capsaicin, the pungent principle of red pepper Nelson first determined that capsaicin is a

[41] H G Barbour *Local anaesthetics* Science N S **51**: 497–504 May 21, 1920

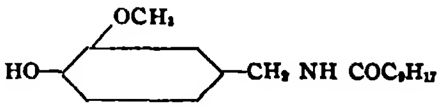
[42] Barbour, op cit

[43] O Gros *Ueber die Narkotika and Lokalanaesthetika.* Arch exp Path u Pharmakol **63**: 80 1910

[44] Cf supra, p 333

[45] *E g*, Dakin's Di-chloramin T.

vanillyl-decenoyl amide.[46]



He thereupon made a series of homologous vanillyl-acyl amides with acids of different molecular weights[47] He found that with increasing molecular weight there was an increase in pungency up to a maximum beyond which it decreased Table 2 gives the relative pungency of these substances, capsaicin being rated at one hundred

TABLE 2—COMPARATIVE PUNGENCIES OF VANILLYL-ACYL AMIDES

Vanillyl n-hexoylamide	5
Vanillyl n-heptoylamide	25
Vanillyl n-octoylamide	75
Vanillyl n-nonoylamide	100
Vanillyl n-decoylamide	50
Vanillyl n-undecoylamide	25
Vanillyl n-dodecoylamide	25
Vanillyl undecenoylamide	25

This phenomenon of increasing intensity of physiological action up to a maximum with increase in molecular weight and a diminution beyond the maximum with still further increase in molecular weight is a phenomenon that has been observed frequently[48] There is good reason to believe that it is due, in part at any rate, to changes in solubility. For example, for a substance to be odorous it must be sufficiently soluble in both water and lipoids, since the cells of the mucous membrane of the nose are covered by a watery fluid and have in all probability a lipoid semi-permeable cell membrane[49] Thus in the homologous series of pungent substances of table 2 the solubility in water decreases with rising molecular weight while the solubility in ether increases Perhaps this is a plain case in which the manner of action, that is, pungency, is a function of the chemical structure of the molecule, while the intensity of action is dependent upon the physical property of solubility Perhaps the specificity of the pungent action is not to be sought in the substances so much as in the taste buds of the tongue, according to the well-known physiological law of the specific response of the nerve end-organs. Any stimulus gives the

[46] E K NELSON *The constitution of capsaicin, the pungent principle of capsicum* Journ Amer Chem Soc 41: 1115 1919

[47] E K NELSON *Vanillyl-acyl amides* Journ Amer Chem Soc 41: 2122 1919

[48] TH H. DURRANS *The relationship between odour and chemical constitution* Perfumery and Essential Oil Record 10: 107–132 London, May 21, 1919

[49] BACKMANN Journ physiol path gen 17: 1

sensation peculiar to that organ The capsaicin series is highly irritating to all cells Perhaps the sensation of pungency is only the effect of the irritation of specific cells on the tongue.

The type of reasoning and of investigation above discussed has been used only recently to produce new repellants for insects, to combat human parasites Moore and Hirschfelder[50] have made such a study upon the body louse and have demonstrated that the impregnation of the garments with certain halogenated cresols will repel this parasite for considerable periods It would seem that here is a wide field for work. Research similar to that of Moore and Hirschfelder should lead to the discovery of repellants for such pests as black-flies and mosquitoes, a boon not merely to those who frequent the swampy lands of our continent but also to those who live in malarial regions

While Moore and Hirschfelder and a few others have made a beginning in this sort of research in relation to insects troublesome to man, but little work has been done to improve or devise better insecticides and fungicides useful in agriculture The economic losses from insect and fungous ravages are enormous. Despite such losses we have been content with relatively few simple insecticides and fungicides The organic insecticides in present use are largely natural plant substances such as the poisons of the hellebore and larkspur, pyrethrum, and nicotine from the tobacco plant In addition, cyanides, long known to be poisonous, and mineral oil emulsions are also used Recently the employment of certain war gases has been advocated Of the inorganic insecticides, arsenates, known for centuries to be poisonous to higher animals, and lime and sulfur sprays represent obvious and readily available substances The use of fluorides represents a rather distinct and valuable discovery No really synthetic organic substance has come into use as an insecticide. It is evident that the range of our insecticide and fungicide armamentarium at the present time is very narrow. There is no reason why this range could not be extended vastly by the development of a sister science to chemo-therapy, a science for which I venture to propose the name chemo-phyto-therapy. The aim of chemo-phyto-therapy would be to protect plants from the attacks of microorganisms and insects just as the aim of chemo-therapy is to protect animals from such attacks. As chemo-therapy demands the working together of pharmacologists and chemists, so chemo-phyto-therapy would demand

[50] W MOORE and A D HIRSCHFELDER *An investigation of the louse problem* Research Publ Univ Minnesota 8: No 4 July, 1919

the working together of entomologists, of pathologists and of chemists The entomologist indeed has a twofold task Not merely must he test out the substances created by the chemist, but he must also create the science of the pharmacology of insects

Some desultory work of this type has been done in the past The Bureau of Entomology of the U S. Department of Agriculture from time to time has tested out numerous substances, often by-products for which no other use was apparent, such substances as naphthols, cresols, crude pyridin bases and many others. These were all found to be comparatively worthless for one cause or another Few if any systematic studies in which the chemist and the entomologist cooperated seem to have been made Such studies are now in progress through the cooperation of the Bureau of Entomology and of the Bureau of Chemistry. Notable progress has been made and it is hoped that a solid foundation will be laid for a new science— chemo-phyto-therapy.

My hope in addressing you was to give you a conception of the pharmacologist which is perhaps not generally current and to indicate to you how fundamental are some of the problems with which he deals If I have succeeded in arousing your interest in this science and if in so doing I have demonstrated to you that the action of chemical substances upon living things is quite as much a function of the physical properties of such substances as it is of their molecular structure, then I have achieved the goal that I set for myself this evening

PETROLOGY —*Petrography of a lamprophyre dike cutting a pyrite body in Boyd Smith Mine, Louisa County, Virginia*[1] THOMAS L. WATSON, University of Virginia.

The important large lens-shaped bodies of pyrite in Louisa County, Virginia, so vigorously worked for many years, are inclosed in schists of probable Cambrian age These pyrite bodies, as well as the more or less closely associated gold deposits, are genetically related to intrusions of plutonic igneous rocks which are exposed in large masses in fairly close proximity to the ore bodies The ore-bearing schists are also intruded in places by dikes of both acidic and basic igneous rocks, the latest of which is diabase of Triassic age

Although the area is one in which igneous rocks, in part younger than the ore bodies, are fairly common, and in which mining operations have been in progress for a long period of years, not until recently

[1] Received June 16, 1921

has a single instance been known where the pyrite bodies were intruded by igneous rocks.

The object of this paper is (1) to place on record observations of the only known case of a pyrite body in one of the principal pyrite mines of Virginia that is cut by a dike of igneous rock, and (2) to give a petrographic description of the rock, since it is unlike the usual types of basic igneous rocks found in the Virginia Piedmont province, and for the added reason that the mine is closed and is no longer accessible

OCCURRENCE

The lamprophyre dike[2] described in this paper cuts the pyrite body in the Boyd Smith mine which is located about 2 miles north of Mineral, Louisa County, Virginia The mine is one of a group of pyrite mines located near Mineral that have yielded large tonnages of ore According to Mr Neustaedter, the dike was encountered in mining pyrite near the north heading of the so-called "west vein" on the first level about 100 feet below the surface The ore body at this level is about 8 feet wide, strikes approximately N 25° E, and dips to the southeast about 60° The dike does not exceed one foot in thickness, cuts the pyrite body in an east-west direction, and dips about 85° south. The same dike was also observed cutting the "east vein" of pyrite There is no evidence of the dike on the surface

PETROGRAPHY

Megascopic characters.—The general appearance of the rock is that of a typical porphyritic basalt It is massive and of dark blue-gray color, with small phenocrysts of biotite and nearly black pyroxene in roughly equal amount set in a dense aphanitic groundmass Polished surfaces of the rock are uniformly darker (nearly black) in color, with groundmass and phenocrysts rather strongly contrasted.

The dark minerals, biotite and pyroxene, are the only ones recognized in the hand specimen Biotite, in small glistening crystals up to 2 mm. in diameter, but usually less than 1 mm, is seemingly more abundant than pyroxene in the hand specimen, but not in the thin section Pyroxene, nearly black in color, is developed in lath-like prismatic crystals up to 5 mm long and 1½ mm thick, and in

[2] Credit for the discovery of the dike belongs to Mr A Neustaedter, former mining engineer in charge, to whom the writer is indebted both for a statement of facts relating to its occurrence and for a hand specimen of the rock The discovery of the dike in 1917 by Mr Neustaedter was communicated to the writer and a hand specimen sent, but pressing duties prevented the earlier preparation of a statement of the interesting occurrence

short prismatic nearly equant crystals up to 4 mm. in diameter. The density of the specimen analyzed is 3 065

Microscopic characters —In thin section the rock shows considerable alteration, especially the goundmass, which is composed chiefly of clay substance admixed with more or less chloritic and serpentinous material, derived probably from either feldspars or feldspathoids or both. Neither feldspar nor glass was observed in the thin section studied, although both may have been present originally The groundmass of the composition indicated above was roughly estimated at 30 per cent

Phenocrysts of biotite, augite, and altered olivine make up probably 60 per cent or more of the rock Augite and much of the biotite are usually fresh, but olivine is completely altered The ore minerals, titaniferous magnetite and apatite, the former predominating, make up chiefly the remaining 10 per cent of the rock No evidence of the presence of sulfide minerals was indicated in either the hand specimen or the thin section

Biotite is of the type usually characteristic of the lamprophyres It exhibits intense pleochroism in shades of light and dark brown, and in part dark-colored resorption rims Much of it is entirely fresh, but some has altered to a faintly pleochroic red substance without trace of cleavage. It usually contains some inclusions

Pyroxene is the variety augite near diopside in composition Most of it is colorless but some individuals show narrow faintly pleochroic borders indicating some admixture of the aegirite molecule Faint violet shades indicating the presence of titanium are also noted The average extinction angle varies from 35 to 40 degrees The augite occurs in several generations and probably formed during the entire period of crystallization of the rock It is developed in subhedral short nearly equant and in elongated prismatic (bladed) crystals, the latter being predominant and so closely resembling in outline lath-shaped plagioclase in diabase as to suggest diabasic texture In extreme cases the augite prisms are more than six times longer than thick A pronounced zonal structure is usually developed in the nearly equant crystals, and some show hour-glass structure. Some crystals show a green core that is faintly pleochroic and sharply defined from the outer colorless part of the individual, others have a pale green faintly pleochroic outer zone enveloping a colorless core. The microscope indicates augite low in iron and in part titaniferous. Cleavage is usually well developed in the nearly equant crystals and

to a less degree in the lath-like forms Twinning is observed in one or two of the crystals

Olivine, originally present in amount roughly estimated at 18 per cent, is completely altered to greenish yellow serpentine, but the outlines of the original mineral are usually well preserved.

CHEMICAL COMPOSITION

The composition of the rock is shown in the chemical analysis given in table 1. It is regretted that fresher material was not available for analysis, for the high water content (5 21 per cent) indicates considerable alteration of the rock, a fact fully confirmed by microscopic study

TABLE 1 —ANALYSIS AND NORM OF LAMPROPHYRE DIKE, LOUISA COUNTY, VIRGINIA

S D GOOCH, ANALYST

SiO_2	37 40	or	15 01
Al_2O_3	18 60	ab	4 19
Fe_2O_3	6 35	an	40 87
FeO	7 95	di	0 68
MgO	3 80	hy	11 67
CaO	11 57	ol	0 48
Na_2O	0 50	mt	9 28
K_2O	2 53	il	7 45
H_2O-	1 89	ap	4 70
H_2O+	3 32		
TiO_2	3 80	Symbol II(III) 5 4 2	
P_2O_5	2 04		
MnO	0 23	No name for II 5 4 2 in the "Quantitative System "	
	100 07		
Sp Gr	3 065		

Because of the altered condition of the rock the norm and mode do not agree There is no name yet for the position in the "Quantitative System" of classification in which the rock falls, or for the next one in salfemane, but it is so altered (over 5 per cent of water) that it seems not advisable to propose one. The high K_2O is undoubtedly contained in the biotite, TiO_2 mostly in the titaniferous magnetite or ilmenite, but partly in the augite, and probably to some extent in the biotite, while the high P_2O_5 is derived from apatite, which is present in larger amount than is usual for the average rock of this type

AGE

The exact age of the dike is unknown The ore body which it cuts is one of several of similar composition occurring in the same district in Cambrian schists The pyrite bodies are genetically related to intrusions of granitoid rocks that may be later but not older

than Cambrian, and with which the dike may possibly be correlated as a late differentiate. The youngest known igneous rocks in the district are dikes of Triassic diabase to which the dike cutting the pyrite body bears no resemblance as it is the first of its kind to be described from the Virginia Piedmont province. It cannot be older than Cambrian and may be as late as Triassic. The rock is more closely allied in mineral composition and structure with the Triassic dikes of basic igneous rocks than with the igneous bodies of earlier age occurring in the area For these reasons the writer regards the dike as being probably not older than Triassic.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

OPTICS.—*Dispersion in optical glasses I.* FRED E. WRIGHT. Journ. Opt Soc. Amer **4**: 148–159. 1920. (Geophysical Lab. Papers on Optical Glass, No 27.)

If partial dispersions alone are considered and plotted one against the other, the result in each case for a series of optical glasses is a straight line. This fact, that in a series of optical glasses the partial dispersions are related by linear functions and that these functions are the same for all glasses, proves that, if a single partial dispersion is given, the entire dispersion-curve is fixed, irrespective of the type of glass. This means that within the limits to which this statement holds, namely, about one unit in the fourth decimal place, if any partial dispersion is given, all other dispersions follow automatically. Thus, a series of standard dispersion-curves can be set up independent of the absolute refractive index. This means that if for any substance two refractive indices be given, the dispersion-curve can be written down directly, that in case two substances of very different refractive indices are found to have the same actual dispersion for one part of the spectrum their dispersion-curves are identical to one or two units in the fourth decimal place throughout the visible spectrum From these relations it is possible to build up dispersion formulas containing two, three, or more constants which represent the data in the visible spectrum with a high degree of exactness. Certain of these formulas are of such form that they are valid far into the infra-red and ultra-violet, but break down of necessity as an absorption band is approached. Certain of the dispersion formulas thus obtained are well adapted for computation purposes. F E W.

GEODESY.—*Elements of map projection with applications to map and chart construction* CHARLES H DEETZ and OSCAR S ADAMS. U S Coast and Geodetic Survey Spec. Publ. **68** (Serial **146**) Pp 163, figs 74, pls. 8. 1921.

The aim of the authors is to present in simple form some of the ideas that lie at the foundation of the subject of map projections Many people have rather hazy notions of what is meant by a map projection, to say nothing of the knowledge of the practical construction of such a projection.

The subject matter is divided into two parts which are intended to meet the needs of such readers The first part treats the theoretical side in a way that is as simple as it can be made, the second part takes up the consideration of the practical construction of some of the most important projections, the intention of the authors being to give such detailed directions as are necessary to present the matter in a clear and simple manner.

The use of mathematical analysis in the first part is studiously avoided since the intention is merely to illustrate the way in which different kinds of projection may arise when we attempt to produce maps with specific properties. Both the first and second part are profusely illustrated with figures that serve to make clear the statements of the text

The projections described in the second part belong mainly either to the conformal class or to the equal-area class Several tables for projections are included, the most important being that of a Lambert-zenithal equal-area projection for the United States or for North America with center on the parallel of 40°, that of an Albers equal-area projection for the United States, and finally, the most important of all, that of a general Mercator projection As a closing section of part two and of the whole treatise, some general consideration is given to world maps, that is, to maps that are intended to include as great an extent of territory as a hemisphere or in certain cases to represent the whole sphere. C. H. D. and O. S. A.

PETROLOGY.—*Italite: a new leucite rock.* HENRY S. WASHINGTON. Amer Journ. Sci. **50**: 33–47. 1920 Atti Accad. Lincei **29**: 424–435. 1920.

A detailed account of the new leucite rock first described in this JOURNAL **10**: 270–272. 1920

ZOOLOGY.—*Report on the ophiurans collected by the Barbados-Antigua Expedition from the University of Iowa in 1918.* AUSTIN H. CLARK. Univ Iowa Studies. Studies in Natural History, 9 (First Series No. 45), No. 5, 29–63. March 15, 1921.

A history of the study of the ophiurans of the Caribbean region is given, with a list of the more important papers, the Caribbean echinoderm fauna is discussed, and the peculiarities of the West Indian ophiuran fauna are analyzed and compared with those of the crinoid fauna of the same region, the discontinuous distribution of the echinoderms is discussed and explained as resulting from the extirpation of ancient types from the more favorable areas in the sea so that they now exist only in isolated localities representing the extreme limits of their original habitat; a complete list of the West Indian ophiurans is given; the occurrence of these animals at Barbados and at Antigua is described, and all previous records from these islands are given, the specimens secured by the expedition are described in detail. A. H. C

ENTOMOLOGY.—*The ants of the Fiji Islands* W. M. MANN. Bull. Mus Comp. Zool. Harvard **64**: 401–499, figs 1–38. No. 5, 1921.

This is a report of the ants collected by the writer while in Fiji as Sheldon Traveling Fellow of Harvard. The insects of Fiji are not well known, hitherto but 53 species of the order Hymenoptera had been recorded from the islands. The present paper lists 78 species of ants, including many new species and several new genera and subgenera. Certain genera of ants are well developed in Fiji, among them the genus *Camponotus*, which is represented by ten forms belonging to a subgenus (*Myrmegonia*) which is confined to

the islands. About 70 per cent of the species listed are supposedly endemic. This number of endemic forms is an unusually high percentage for an island fauna and indicates a very long isolation.

In a preliminary discussion of the zoogeographical position of the islands it is shown that the ant fauna is not related to that of any one region but consists chiefly of types that formerly were of wide distribution and thus supports the idea that Melanesia has served, as far as the land fauna is concerned, as a biological conservatory. Fiji is the eastern limit of this region and has been isolated longer that the islands further west. W M. M.

ENTOMOLOGY.—*Diptera of the superfamily Tipuloidea found in the District of Columbia.* C. P ALEXANDER and W. L. MCATEE. Proc U S. Nat. Mus. **58:** 385–435, pl 26

This paper forms another one of the series of insect papers which endeavors to make it possible for local workers to become acquainted with the fauna of the District of Columbia and vicinity. The insects belonging to the superfamily Tipuloidea were commonly called crane-flies, and this paper tabulates all the species known to occur locally, gives notes on the habits of the adults and larvae, and distribution and dates of flight of the various species. The introduction briefly summarizes the history of this science as far as pertains to this region and the paper is followed by a bibliography of titles. One plate illustrates the venation. 40 genera are included. Of the species listed 87 are described from material which was collected in this region, chiefly by the activities of the late C. R. Osten Sacken. S A. ROHWER.

ENTOMOLOGY.—*A revision of the North American species of Ichneumon-flies belonging to the genus* Apanteles. C F. W. MUESBECK. Proc U. S. Nat. Mus. **58:** 483–576. 1921.

The Ichneumon-flies of the genus *Apanteles* are small, usually black, insects which in the larval stage are parasitic on the larvae of lepidopterous insects. The above-mentioned paper is a revision of the species of North America, including the West Indies. The revision is based largely upon the extensive collections of the National Museum and 164 species are recognized. The types of most of the species have been studied by the author and besides pointing out some synonymy he has described 36 new species The descriptive part of the paper is preceded by a synoptic key and followed by an aphabetical list of hosts, and a species index. S A ROHWER

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

849TH MEETING

The 849th meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club on March 26, 1921 It was called to order by President FARIS, with 65 persons present. The program was as follows.

O. S ADAMS *Authalic latitude, a cartographic expedient* (Illustrated)

It has been found by many scientific investigations of various kinds that the shape of the earth, as a whole, is very nearly that of an ellipsoid of revolution with the equatorial diameter about 26 miles longer than the polar diameter, the axis of rotation of the generating ellipse It is evident that

some regular body of this kind must be adopted to form the surface of reference for geodetic investigations as well as for geographical purposes; any irregularities that may be found to exist are viewed as departures from this regular form and can be taken into consideration, as such, whenever necessary.

Since this spheroid is taken as the surface of reference, it becomes the problem of cartography to take it into account in all mapping projects. It is comparatively easy to determine projections of various kinds for the sphere, hence mapping can be simplified if we determine an intermediate projection of the spheroid conformally upon a sphere with radius equal to the equatorial radius of the earth This is done by applying a correction to the geodetic latitude and results in what is called the isometric latitude. In considering equal-area mapping of the spheroid with this fact in mind, the idea arose that the spheroid could be projected equivalently upon a sphere of equal surface by computing a correction to the geodetic latitude, the longitude being left unchanged just as in the case of the conformal mapping. This sphere could then be mapped upon the plane by any desired equal-area projection, and the result would be an equal-area projection of the spheroid. This idea of an intermediate projection was then developed analytically and the resulting latitude has been christened *Authalic latitude*. The term "authalique" was used by Tissot as a general term for equal-area. Authalic latitude is therefore "equal-area" latitude.

The difference between the geodetic latitude has been developed in a Fourier series and tables computed for every half degree of latitude. These results are published in U. S. Coast and Geodetic Survey Special Publication No. 67, entitled *Latitude developments connected with geodesy and cartography*

The paper was discussed by Messrs C. A. BRIGGS, PAWLING, SOSMAN and WILLIAM BOWIE

E. A. ECKHARDT and J. C. KARCHER *A chronographic recorder of radio time signals*. (Presented by Mr. ECKHARDT, and illustrated with slides and a demonstration of the apparatus)

The radio time signal recorder described in this paper was devised at the Bureau of Standards for the field use of the Coast and Geodetic Survey By its use the Survey will be enabled to record simultaneously on a chronographic drum the time signals sent out by Annapolis on the breaks of the local chronometer without mutual interference. Radio signals originating at Lyons, France, may be recorded at the Bureau of Standards whenever that station is sending, the air line distance between sending and receiving stations being approximately 3800 miles. It is inferred, therefore, that the sensitivity of the apparatus is sufficient to record Annapolis time signals at any field station which the Coast and Geodetic Survey may occupy anywhere within the borders of the United States.

The apparatus is sufficiently rugged for field service, and a 50-foot, 6-wire flat-top antenna 40 feet above the ground is sufficient for all ordinary conditions.

The radio apparatus proper may be used with any kind of chronograph drum or tape recorder. Dot and dash signals are indicated by short and long excursions of the recording pen from the datum line. In an Annapolis time signal these excursions are $^1/_3$ of a second long, while the pen traces the datum line during $^2/_3$ of every second

The receiver equipment includes a regenerative electron tube circuit in the plate circuit of which there is a telegraph relay This regenerative circuit starts to oscillate when the grid potential is made to exceed a certain critical

value. The passing of the circuit from the non-oscillating to the oscillating state results in a rise in plate current sufficient to operate the telegraph relay. The operation of the relay results successively in a pen excursion and in the killing of the local oscillations. The circuit is thus restored to the receptive state and the pen to the datum line.

A very small change in grid potential is sufficient to start oscillations if the grid potential is initially adjusted to a value near to and just below the critical potential. This potential rise may be provided by a radio signal received on an antenna suitably related to the regenerative circuit.

The circuits are so located that during the reception of radio signals the breaks of a local break-circuit chronometer may be recorded simultaneously by means of the same pen. This obviates lags which would be encountered if independent pens were used.

850TH MEETING

The 850th meeting of the Philosophical Society was held in the Auditorium of the Cosmos Club on April 9, 1921. It was called to order by President Faris with 31 persons present.

The first paper, on *Mollier diagrams*, by E. F. MUELLER and C. H MYERS, was presented by Mr. Myers and was illustrated.

In 1904 Mollier published an article[1] in which he described the properties of heat content and its uses in refrigeration problems. This article is illustrated with (1) a heat content-entropy diagram with rectangular coordinates for steam, (2) a heat content-entropy diagram with oblique coordinates for CO_2, and (3) a heat content-pressure diagram for CO_2.

In the present paper the properties and uses of heat content were discussed, and illustrations of six diagrams shown in which the ordinates were heat content and the abscissas were entropy (rectangular coordinates), entropy (oblique coordinates), volume, log volume, log pressure, and a scale of pressure corresponding to a uniform scale of saturation temperature, respectively

The choice of coordinates is a matter determined by conditions Where the whole range from saturated liquid to a considerable superheat in the vapor is required the heat content-entropy diagram is poor even with the oblique coordinates since it covers only a small portion of the paper and the lines cross at sharp angles. The use of volume as abscissa is very little if any improvement, although the use of log volume is much better. The diagrams in which a function of the pressure serves as abscissa are very readable, although the pressure corresponding to a uniform temperature scale is probably the best when the diagram does not extend above the critical

Some function of the heat content might be used for the ordinate in order to magnify the scale in parts desired to be especially accurate. The use of uneven coordinates should cause very little trouble if sufficient lines are entered in the diagram so that linear interpolation may be used.

The second paper, on *The heating of substances by expansion*, was presented by Mr. L H ADAMS, and was illustrated.

The pressure to which a fluid is exposed may be released by three principal methods

(1) Isentropic expansion, *i.e.*, at constant *entropy*

(2) Isenergic or explosive expansion, *i e.*, at constant *energy*

[1] Zeitschr Ver Deutscher Ingenieure

(3) Isenkaumic or extrusive expansion, *i.e.* at constant *enkaumy*,[2] or constant heat content.

These three methods were discussed and attention was called to the large heating effects when liquids are expanded according to (3). Thus, water by expansion through a porous plug from a little over 4000 atmospheres should heat itself from 20 deg to 100 deg. C.

Although the ordinary thermodynamic equations are applicable only to fluids, at pressures far in excess of their ultimate strength solids fulfill to a sufficient extent the condition of equality of pressure in all directions, and therefore the equation for isenkaumic expansion may be applied to such phenomena as the extrusion of wires and other solids through small openings.

The paper was discussed by Messrs. WHITE, MUELLER, C. A. BRIGGS, and HUMPHREYS.

The third paper, on *Specific and latent heats of nickel and monel metal*, was presented by Dr. W. P. WHITE, and was illustrated.

The addition of heat makes all bodies hotter, but the amount of heat required to raise a body 1 degree is different for different bodies. This quantity is the specific heat. It has important relations with the nature of atoms and energy. The principal key to this relation was one of Einstein's earlier discoveries The specific heat at high temperatures is also of practical importance in the treatment of metals, fire brick, and all materials which have to be heated or cooled An important economy in portland cement manufacture was effected some years ago by a recovery of heat based on a knowledge of the specific heat of the cement at high temperatures

The simplest way to determine specific heat is to give a sample of the material in question a known amount of heat by means of an electric heater, measuring the change in temperature produced. This method works best in a vacuum and at low temperatures where the heat losses are small It is almost the only method used at the low temperatures of liquid air and liquid hydrogen Its value at high temperatures is questionable, and it has been little used The irregularity which is unavoidable in most electric furnaces and the very rapid rate of heat loss at such temperatures are both difficulties It is possible that by improved technique this method might be used at high temperatures. If so, it would be a very interesting research.

A more successful method at high temperatures is to heat a body in a furnace and then drop it into a water calorimeter so that the most difficult measurement, the measurement of heat, is carried out at room temperatures with all the refinements of modern technique The only thing to be done in the furnace is then the heating of a body to constant temperature, for which abundant time can be allowed. The greatest source of error is still in the furnace, but this can be diminished if the distribution of temperature within the furnace is carefully studied. If the material is a metal which will oxidize in air it must be protected. One very ingenious method had been the inclosing of the furnace in a high vacuum A long tube, also evacuated, led down into the calorimeter so that the body was in a vacuum from beginning to end In work at the Geophysical Laboratory, the metal specimens were sealed up bulbs of silica glass which held up to 1450° C., the melting point of nickel, although they were somewhat soft at that temperature. Ordinary glass would have run like molasses in April at this temperature. The heat that may be lost in dropping the body through the air is not so serious as might be supposed, but it cannot be neglected. This source of error was

[2] A proposed new term derived from the Greek καυμα, heat

eliminated in the present work, by first dropping empty containers and subtracting the heat given out by the empty container. If the heat loss is the same in each drop the subtraction eliminates it To keep it the same it has been found necessary not to allow the escape of steam, which is likely to be irregular. Hence, second, the calorimeter contained a steam dome into which the steam could rise without getting out. A quick drop has often been accomplished by melting a platinum wire from which the specimen was hanging. After considerable trial a mechanical arrangement for dropping has been developed which is more convenient and less expensive. It was necessary to find a suitable material and then a compact design not calling for great strength.

The only results for many metals at high temperatures were recently obtained by three German investigators, who used the vacuum-closed furnace already mentioned The results obtained in the Geophysical Laboratory for the latent heat of nickel were about 30 per cent higher than theirs. It is believed that the Geophysical Laboratory method, though simpler and easier to carry out, was free from several sources of error caused or aggravated by the limitations of working in vacuum, and that the result obtained at the Geophysical Laboratory, 73 calories per gram for the latent heat of nickel, is accurate at least to 5 per cent

The paper was discussed by Messrs FOOTE, MUELLER, SOSMAN, and others.

H. H. KIMBALL, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Observations have recently been made by a Coast and Geodetic Survey party on the *Explorer* to verify the magnetic disturbance reported in the vicinity of Sentinel Point, southeastern Alaska. The maximum disturbance was found to be just west of the Point, the ship's compass changing its direction 55 degrees within a very short distance. The disturbance extends entirely across Port Snettisham, at one place amounting to more than 20 degrees in midchannel.

The securing of sea-water densities and temperatures has been begun by the Coast and Geodetic Survey observers at Portland, Maine, and Boston, Massachusetts It is the intention of the Survey to secure similar observations at all the principal tidal stations.

At the invitation of Mr. NORTHCOTT, owner of the Luray Caverns, Virginia, Dr. ALES HRDLICKA of the National Museum visited the caverns on June 27 for the purpose of examining and removing certain bones, enclosed in stalagmite, which were believed to be human. After considerable difficulties, the entire deposit containing the bones was taken out in pieces which showed the remains of most of the parts of a human skeleton, but no trace remained of the skull with the exception of a portion of the lower jaw. The specimens have been donated to the Museum for further study.

The headquarters of the Chemical Warfare Service in Washington have been moved from the temporary buildings at 1800 Virginia Avenue to the seventh wing of the Munitions Building

The Fixed Nitrogen Research Laboratory, together with about a half million dollars from the original appropriation made for the investigation of nitrogen fixation, was transferred on June 30 from the jurisdiction of the War Department to the Department of Agriculture The Laboratory is now an independent unit of the Department of Agriculture, under the direction of

Dr. RICHARD C. TOLMAN, who has the assistance of an advisory committee made up of a representative of the War Department and representatives of the agricultural bureaus which are directly interested in the fixation of nitrogen. It is expected that the present allotment will maintain the Laboratory about two years.

A farewell dinner to Dr. CARL L. ALSBERG, chief of the Bureau of Chemistry, U. S. Department of Agriculture, was given at the Cosmos Club on June 17 by the chiefs of bureaus of the Department. Dr Alsberg left Washington in July to become director of the new Food Research Institute established by the Carnegie Corporation at Stanford University, California.

Mr. CHARLES H. BEHRE, Jr, of Illinois, has been appointed assistant geologist with the U. S. Geological Survey.

The following have been appointed geologic aids with the U. S. Geological Survey Messrs. WILMOT H BRADLEY, of Connecticut, PLATT C BENEDICT, of Massachusetts, JAMES GILLULY, of Washington, HAROLD W. HOOTS, of Kansas, KENNETH K. LANDES, of Washington, and LLOYD W FISHER, of Pennsylvania

Mr MILTON N. BRAMLETTE, of Wisconsin, has been appointed assistant geologist with the U. S Geological Survey.

Dr HARDEE CHAMBLISS, formerly research chemist with the General Chemical Company, and lieutenant colonel in charge of U S Nitrate Plant No 1 during the War, has been appointed to take charge of the work of the department of chemistry at the Catholic University on account of the prolonged illness of Rev. Dr. JOHN J. GRIFFIN, who has been in charge of the department since 1895.

Mr LLOYD C FENSTERMACHER, of Pennsylvania, who was recently appointed assistant geologist with the U S Geological Survey, was killed on July 9 in an automobile accident while engaged in field work for the Survey near Wilder, Montana

Mr. G. J. FINK, formerly with the Hooker Electrochemical Company of Niagara Falls, is now associated with Dr. M E. HOLMES in the chemical department of the National Lime Association in Washington.

Mr. PAUL M. FRANK, of Allentown, Pennsylvania, has been appointed assistant curator in the Division of Mineral Technology of the National Museum

Dr MICHAEL E. GARDNER has been apointed chief of the bureau of preventable diseases and director of the bacteriological laboratory of the U S Public Health Service

Mr JOSEPH L. GILLSON of Illinois has been appointed assistant geologist with the U. S Geological Survey.

Dr. F. H. KNOWLTON of the National Museum received the honorary degree of Doctor of Science from Middlebury College in June.

Mr. CHARLES E. MIRGUET, who has been associated with the National Museum for several years, has been appointed taxidermist to succeed the late Mr. WILLIAM PALMER.

The sections of Eastern and Western Areal Geology in the U. S Geological Survey have been merged into one section under the direction of Mr SIDNEY PAIGE

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GENERAL SCIENCE.—*A list of one hundred popular books in science.*[1] Compiled by a committee of the WASHINGTON ACADEMY OF SCIENCES.

At the request of Dr George F. Bowerman, Librarian of the Public Library of the District of Columbia, a committee of the ACADEMY has undertaken the compilation of a list of scientific books which can be recommended for popular use. The Editors believe it to be of sufficient interest to the members of the ACADEMY and other readers of the JOURNAL to warrant the preliminary publication of the report, particularly as it is hoped that criticisms and suggestions from readers may be brought forth and the list thereby improved. It is to be emphasized that the list is strictly tentative, and that neither the Committee as a whole nor any one member of it can assert that the books named are the very best for the purpose. It will be obvious also that broad areas of the field of science are hardly touched at all, and that the relative number of books treating of different subdivisions of science must not be taken to represent the relative importance of each subdivision or the relative activity of modern research therein *Readability* is an essential criterion for selection, and books that are "readable," from the public's point of view, are very unevenly distributed as to subject-matter.

The first test for the kind of book that is desired for the list is this. Would the average reader who uses a public library, after beginning to read the book in question, read it through to the end and come back to the Librarian for another on the same subject? Such a book should be included. Or would he lay it down after a little while and turn to some other kind of book as being more interesting, and not return to the subject again? Such a book should not be included,

[1] Received August 25, 1921.

however accurate, thorough, and complete it might be from the standpoint of a specialist.

It is also desirable that the book should not be professedly a text-book, nor should it be written in text-book style; that is, it must not be a book intended primarily for the seeker after information regardless of whether the information be interesting reading or not. It is perhaps needless to add that it should have been written by an author who knows his subject thoroughly, and should not be so old as to be obsolete in its facts and speculations.[2]

The user of such a list may well be reminded at the outset that the field of science is not sharply divisible into little compartments labeled "Chemistry," "Botany," and the like. On the contrary, there is one vast field of human knowledge, and facts concerning any part of that field have a bearing on every other part. The usual subdivisions, which are those employed here, are not fundamental; they are largely accidental and have arisen merely as a matter of human convenience.

If we believe with Pope that "The proper study of mankind is Man" we may well begin with books about Man himself, rather than follow the austere and logical order laid down by philosophers, beginning with mathematics and ending with sociology. The natural order of human education is just the reverse, beginning with impressions of human nature and reaching formal logic and philosophy last, if ever. In this preliminary list, however, the Committee does not attempt to recommend any books in the fields of psychology, sociology, and related sciences, but begins with Man considered rather as a species or as an organism, suggesting the following books in anthropology and physiology:

[2] These specifications are not easy to meet. Popular scientific books of a class which might be described as "interesting if true" are not uncommon, but the production of such books seems to demand primarily a sufficient dearth of conscience and professional pride on the part of author and publisher. Others fall on the borderline between the merely "unorthodox" and the "misleading" or "misinforming." It is no great objection to a popular scientific book that its speculations are somewhat wild, provided its statements of fact and principle are based on knowledge and not on ignorance.

Librarians and interested readers can be depended upon to compile lists of scientific books that are interesting, but they have no good way of finding out which of these are reliable. It is here that the ACADEMY can do a service, for there are on the shelves and recommended in library lists books of popular science which, under even the most liberal of "pure food laws" for books, ought to be labeled "misbranded" or "adulterated" if not "poisonous." They are particularly common in those branches, such as meteorology and anthropology, in which every man considers himself something of an expert.

MASON, O. T. *The origins of invention.* 419 pp. ("Contemporary Science Series," Walter Scott, London, 1895.) Although old, this book is thoroughly reliable and will remain authoritative for decades to come. It is readable and entertaining, and at the same time based on a wide knowledge of anthropology and ethnology.

MASON, O. T. *Woman's share in primitive culture.* 295 pp. (D. Appleton and Co., New York, 1894.) Like the preceding book by the same author, this work remains a standard. It will be particularly welcome to readers who have been irritated by the irresponsible pseudo-science that is sometimes written about the relative status of the sexes in primitive, as compared with modern, society.

OSBORN, Henry Fairfield. *Men of the Old Stone Age, their environment, life and art.* 545 pp., 268 illustr., 33 pp. of bibliography and index. (Charles Scribner's Sons, New York, 1915.) This book is a popular synthesis of the findings and opinions of many specialists, including the author himself, in the fields of archeology, paleontology, geology, anthropology and primitive art.

HADDON, A. C. *The study of man.* 410 pp. (G. P. Putnam's Sons, New York, 1898.) A reliable and readable work by one of the foremost ethnologists and anthropologists of Great Britain. It deals interestingly with the distribution of Man and his varieties over the Earth's surface.

KIDD, Dudley. *Savage childhood, a study of Kafir children.* 314 pp., 32 illustr. from photographs. (Adam and Charles Black, London, 1906.) This book is less general than the preceding but it is particularly attractive. The games, stories and songs of Kafir children as well as Kafir customs pertaining to children are described in a charming and instructive manner The book is artistic rather than scientific but is a distinct addition to popular knowledge of anthropology and ethnology.

HOUGH, Walter. *The Hopi Indians.* 265 pp. (Torch Press, Cedar Rapids, Iowa, 1915.) This is one of the best examples available of descriptive anthropology applied to a particular group. It is entertainingly written, and the author's long experience in the field is a guarantee of its accuracy.

MCCOLLUM, E. V. *The newer knowledge of nutrition.* 199 pp. (The Macmillan Co., New York, 1919.) This book contains an authoritative, non-technical statement of the principles underlying proper human nutrition as developed from a great number of experiments and observations, some of the experiments having been carried out by the author and described by him in an interesting way in the book, with illustrations. The literature on the subject of nutrition has been surveyed and condensed reference is made to this extended field.

SHERMAN, H. C. *Food products.* 594 pp. (The Macmillan Company, New York, 1918) The chemistry, physiology, availability and economics of human foodstuffs are authoritatively discussed in essentially nontechnical language.

Man shares with every other member of the animal and vegetable kingdoms that remarkable capacity, still a mystery to every investigator, whether biologist, chemist, or physicist—the capacity of reproducing his kind and handing down his qualities to his descendants The following books on heredity are standard works in this field

DARWIN, Charles. *The origin of species* (with additions and corrections from sixth and last English edition). 338 pp. (D. Appleton and Co., New York, 1917.) No collection of works on biology should be without this classic. The observations of Darwin are still the current material in biological discussion. His brilliant imagination, together with the thorough and painstaking way in which all conclusions are checked and tested without bias, cannot fail to impress the reader that the study of heredity is a noble and engrossing subject.

EAST, E. M., and JONES, D. F. *Inbreeding and outbreeding.* 285 pp. (Lippincott Co., Philadelphia, 1919.) Although confined to a restricted field, this work presents the most modern interpretation of the phenomena of inheritance in comprehensible form.

CASTLE, W. E., COULTER, J. M., DAVENPORT, C. B., EAST, E. M., and TOWER, W. L. *Heredity and eugenics.* 315 pp. (Chicago University Press, 1912.) A collection of lectures proposed for an audience not especially trained in biology. Although many important facts have come to light since these lectures were delivered, they give, in readable form, the general conceptions of heredity that are held by leading investigators.

MORGAN, T. H. *A critique of the theory of evolution.* 197 pp. (Princeton University Press, 1916.) The author is one of the foremost investigators of heredity. His work in the field of genetics, together with that of his students, has resulted in discoveries that rank with those of Mendel. This book, written for undergraduates, is semi-popular in style and although special emphasis is laid on the phases of the subject in which the author is especially interested, it introduces the reader to the important discoveries made in genetics.

CONKLIN, E. G. *Heredity and environment.* Third edition. 361 pages. (Princeton University Press, 1919.) Newer and technical aspects of a difficult science are not shunned in this treatise but the direct bearings of the results of recent studies in this field upon the welfare and the future of man are presented in a most readable manner.

GALTON, Francis. *Hereditary genius.* 390 pp. (D. Appleton and Co., New York, 1884.) Old, but emphasizes in a delightful way the most important side of genetics.

POPENOE, Paul, and JOHNSON, R. H. *Applied eugenics.* 459 pp. (Macmillan Co., New York, 1918.) A clear and forceful presentation of the bearing and importance of studies in heredity as applied to the human race.

Certain phenomena are common to all kinds of living organisms, whether "animals" or "plants." Reproduction and inheritance have already been spoken of, but there are also growth, and death, and standing behind them waiting to be explained in terms that satisfy the physicist as well as the biologist the fact of evolution:

THOMSON, John Arthur. *The wonder of life.* 658 pp. (A. Melrose, Ltd., London, 1915.) "An unconventional introduction to Natural History and Biology, taking broad views of the actual lives of living creatures and working inwards." A bookful of "wonders," not exploited for the curious, but all bringing their evidence to bear on general laws of life and its evolution.

HEADLEY, F. W. *Problems of evolution.* 373 pp. (Crowell and Co., New York, 1900.) The author is a skilled lecturer and introduces his book with an elementary chapter for the general reader, also avoiding technical terms throughout the work.

LOTSY, J. P. *Evolution by means of hybridization.* 166 pp. (M. Nijhoff, The Hague, 1916.) A brief and stimulating essay on the origin and transformations of living beings.

On the more purely descriptive side of the biological sciences there exists a wide variety of books. It is convenient to roughly divide the field into "zoology" and "botany," and the following readable books in each of these two subjects can be recommended:

In zoology:

BUCKLEY, A. B. *Life and her children.* 312 pp. (Appleton and Co., New York, 1881.)

BUCKLEY, A. B. *The winners in life's race.* 367 pp. (Appleton and Co., New York, 1883.)

These two books are elementary but fascinating, forming a delightful introduction to the study of invertebrate and vertebrate zoology, respectively.

In botany:

GANONG, W. F. *The living plant: a description and interpretation of its functions and structure.* American Nature Series. 478 pp (Henry Holt and Co., New York, 1913.) A thoughtful and suggestive book by a leading American plant physiologist. Written in the form of an essay rather than the usual college text-book and designed to appeal to those interested in knowing how living things "work," rather than to professional botanists. Well illustrated

OSTERHOUT, W. J. V. *Experiments with plants.* 492 pp. (The Macmillan Co., New York, 1905.) An introduction to plant physiology with descriptions of many ingenious experiments requiring only simple home-made apparatus. The author is one of the leading plant physiologists of the United States. The reader should take note, however, that much progress has been made in this branch since 1905

SORAUER, Paul. *A popular treatise on the physiology of plants for the use of gardeners or for students of horticulture and agriculture.* Translation by F. E. Weiss. (Longmans, Green & Co., London, 1895.) This well-written and comparatively brief but highly authoritative work presents a very satisfactory treatment of the structure and nutrition of plants. It might be entitled "the plant at work." As the subtitle indicates, the practical application of the principles set forth is constantly in view.

LUBBOCK, John (Lord AVEBURY). *Flowers, fruits and leaves.* Nature Series. (Macmillan Co., New York, 1908) A readable and suggestive little book by the well-known statesman and botanist.

A special field of botany is that devoted to the distribution of plants over the earth's surface—ecology:

HARDY, Marcel E. *The geography of plants.* 339 pp. (Clarendon Press, Oxford, 1920.) A short readable account of the distribution of vegetation over the surface of the Earth. It is concerned largely with distribution, and only to a slight extent with the relations of plants to their environment.

There are many books dealing in an interesting way with restricted groups of living organisms. Some describe the life of a given locality; some tell about the members of a certain family, wherever they may be found. It is much easier to make a list of good manuals

and information-books in this field[3] than to select a list of the type described in our specifications, but the following will serve as good introductions:

DARWIN, Charles. *Insectivorous plants.* 462 pp. (Appleton and Co., New York, 1896.) An extremely interesting book, and a classic for nearly fifty years. Darwin did his work so thoroughly and well that no one else has touched the subject since to add anything of importance.

TOWNSEND, C. W. *Sand dunes and salt marshes.* 311 pp. (Dana Estes and Co, Boston, 1913.) A very readable and interesting book, highly suggestive to anyone spending a vacation at the seashore. Contains much about plant and animal life, and the physiography of the shore region.

The zoologists have provided more abundantly the kind of books wanted for this list than have the botanists, though their subject matter is hardly more diverse. A sketchy view of their field, beginning with the mammals and coming down the scale to the protozoa, may be had from the following books:

STONE, Witmer, and CRAM, W. E. *American animals. A popular guide to the mammals of North America north of Mexico.* 318 pp. (Doubleday, Page and Co., New York, 1902.) Not simply a manual, but a good book to look through and read. It is abundantly illustrated with plates and half-tones, and tells just the things about the mammals that the average reader who has met them in the woods or seen them in the "Zoo" is interested to know.

ROOSEVELT, Theodore. *African game trails.* 583 pp. (Charles Scribner's Sons, New York, 1910.) No American needs to be told that the late ex-president was one of the most versatile of men. Though some of his critics accused him of substituting vigorous assertion for calm argument his zoological writings have often proved to be more reliable than others with a greater appearance of erudition.

BEEBE, C. *Jungle peace.* 297 pp. (Henry Holt and Co, New York, 1919.) A combination of zoology and philosophic reflections which makes very interesting reading, written by a keen and scientifically trained observer.

CHAPMAN, Frank M. *Camps and cruises of an ornithologist.* 432 pp. (D. Appleton and Co., New York, 1908.) Bird books for nature lovers are abundant, but are usually written for a particular locality. This one of Chapman's can be read with interest and profit in any part of the United States, and its author is a recognized authority in his subject.

HERRICK, F. H. *The home life of wild birds.* 148 pp (G. P. Putnam's Sons, New York, 1901.) Although the author's subtitle calls the book a description of "A new method of the study and photography of birds," it is much more than that. His methods are interestingly described, but are followed up with entertainingly written examples of the additions that anyone who is really interested can make to ornithological science.

FABRE, J. H. *Social life in the insect world.* (Translation by Bernard Miall.) 327 pp. (Century Co., New York, 1912.) It is difficult to select from Fabre's books. All of them might well be recommended for such a

[3] The preliminary circulation of this list has evoked so many requests for a list of reliable manuals which students in one branch of science can depend upon for information in other branches, that the publication of such a list is recommended to the attention of a future committee.

list as this. They are most interestingly written, and while they are not free from minor inaccuracies, no book dealing with so complex a subject as a living organism can hope completely to avoid that criticism

PECKHAM, S. W , and PECKHAM, E. G *Wasps, social and solitary* 310 pp. (Houghton Mifflin Co , Boston, 1905) A well written record of the habits of our common wasps. Mr. and Mrs. Peckham spent years in careful and patient observation, and have written some of our standard manuals, as well as this very popular work

MAETERLINCK, Maurice *The life of the bee* (Translation by Alfred Sutro.) 427 pp (Dodd, Mead and Co , New York, 1902) The author is more widely known as a poet and dramatist than as a zoologist, but he is also a careful student and observer and has contributed in this work one of the reliable books in its field

DARWIN, Charles *The formation of vegetable mould through the action of worms* 302 pp (D Appleton and Co , New York, 1892) A model of the scientific method of attacking a biological problem.

BLATCHLEY, W. S *Gleanings from nature* 348 pp (Nature Publishing Co , Indianapolis, 1899.) One of the few books that give a popular and at the same time accurate account of our common reptiles The book contains also observations of many other animals and plants

ABBOTT, Charles C *Upland and meadow* 397 pp. (Harper and Bros., New York, 1886) A charming book by an author who devoted his life to the study of living organisms as they appeal to the "naturalist"—a type of scientist which has become, temporarily, we may hope, almost extinct.[4]

MAYER, Alfred G *Sea-shore life.* 181 pp. New York Aquarium Nature Series (A. S. Barnes and Co., New York, 1906) A book intended for readers who may be unfamiliar with the technical terms in use among specialists Every dweller or visitor at the sea-shore will find it of interest, though most of the illustrations are of species along the northern Atlantic coast of the United States

Uncounted multitudes of species of living organisms have risen and then declined in past ages. Their study is far from being the dry subject that the word "bones" suggests·

LUCAS, F. A *Animals of the past* 258 pp (McClure, Phillips and Co., New York, 1902.) A very entertainingly written book about a few of the better known or more remarkable of the extinct animals of the ancient world, written partly "to ease the strain on these venerable animals, caused by stretching them so often beyond their due proportions "

HUTCHINSON, H. N. *Extinct monsters and creatures of other days a popular account of some of the larger forms of ancient animal life* 329 pp (Chapman and Hall, London, 1910.) The field selected by the author is that part of paleontology which is best adapted for arousing and holding the interest of the general reader. Technicalities have been omitted as far as possible. A fairly good idea is given of the progress of animal life through the geologic ages. Copiously illustrated, with many restorations

[4] Good books of travel, exploration, and adventure written by scientists, or by persons who are keen observers of natural phenomena, are fairly numerous Such are Thomas Belt's *The naturalist in Nicaragua* (306 pp , Dutton and Co , New York, 1911), and Lyell's *Travels in North America*, but as librarians usually place such books with "travel and description" or some similar classification, no attempt at a selection will be made here The ACADEMY could do a service by preparing a list of reliable books of this kind.

There are not many hard and fast lines of division in science, but there is one that so far has not been wiped out—the line between "living" and "dead" matter. For the rest of our booklist we shall be dealing with sciences not primarily concerned with organic life. The first general group of these is comprehended under the term "geology," including all the sciences which are concerned with the Earth as a whole, with the constitution and structure of its surface and its interior, and with the existing evidences of its past history:

DWERRYHOUSE, Arthur R. *Geology.* 301 pp. ("Romance of Reality" Series. T. C. and E. C. Jack, London and Edinburgh, about 1917.) This up-to-date book is attractively written in clear and simple language for the general reader by a competent geologist. The larger part of it is devoted to the description of an imaginary geological excursion to a hypothetical country. Thus the book loses something of its force from the fact that its descriptions are not taken from actually known and named localities. In the course of the supposed excursion many interesting geologic facts are brought out and are made to bear directly upon the history of the country and upon the development of its natural resources. Methods of field study are also shown.

SEELY, H. G. *The story of the Earth in past ages.* 190 pp. (Appleton and Co., New York, 1910.) An elementary little book, with references mostly to British geology, but containing much matter of general interest.

COLE, Grenville A. J. *The changeful Earth.* 223 pp. (Macmillan and Co., Ltd., London, 1911.) "Inspiration rather than information" is the keynote of the series of which this little book is a member, and it is most effectively carried through, yet without sacrifice of accuracy.

LULL, R. S., and others. *The evolution of the Earth and its inhabitants.* 208 pp. (Yale University Press, New Haven, 1918.) A very readable book, well illustrated, and written by a group of skilful and inspiring lecturers (Barrell, Schuchert, Woodruff, Lull, and Huntington).

BALL, Robert S. *Time and tide.* Third edition. 192 pp. (Society for Promoting Christian Knowledge, London, 1895.) Justly described as a "Romance of the Moon." Two lectures in popular language devoted to the evolution of the Earth-Moon system.

SPURR, J. E., Editor. *Political and commercial geology and the world's natural resources.* 562 pp. (McGraw-Hill Book Co., New York, 1920.) The political and commercial aspect of Earth-science is usually put under the heading of "geography." This book is in that sense a geographic book, for it tells of the location and accessibility of the world's mineral supplies rather than of their origin and geologic relationships. Mr. Spurr is well fitted to present this readable and accurate account of the subject by his training as an editor, mining geologist, and member of the Government's boards on war minerals.

BRIGHAM, Albert P. *Geographic influences in American history.* 285 pp. Chautauqua Home Reading Series. (Chautauqua Press, Chautauqua, New York, 1903.) A popular account by a well-known American geographer. The treatment is unbiased and scientific; the presentation is orderly, thorough and mainly accurate, though weak in some details; the style readable, not catchy, but attractive and stimulating.

Water is perhaps the most active of all the agents that are continually modifying the surface of our changeful Earth:

BONNEY, T. G. *The work of rains and rivers.* 144 pp. Cambridge Manuals of Science and Literature. (Cambridge University Press, England, 1912.) This is practically the only modern book in its field. It can be called neither abstruse nor popular, but is written in fairly simple language suitable for the reader of average education, and is a logical, thorough, and accurate presentation.

CORNISH, Vaughan. *Waves of the sea and other water waves.* 374 pp. (Open Court Publishing Co., Chicago, 1911.) A well written book in non-technical language, beautifully illustrated, dealing in descriptive form with the size, speed, and action of waves in the sea and in rivers.

Volcanoes, although they represent only one among dozens of agents that are active in altering the Earth's surface, have always focussed popular attention upon themselves by the amount of noise they can make and the amount of human destruction they can do in a short time:

BONNEY, T. G. *Volcanoes, their structure and significance.* 321 pp. (G. P. Putnam's Sons, New York, 1899.) By taking up in narrative style the characteristics of some "live" volcanoes the author leads the reader on to do some thinking and speculating for himself as to the cause of volcanicity—and there is still much room for study though important additions to our knowledge have been made since this book was written. Nevertheless, the new facts have by no means rendered this excellent work obsolete.

RUSSELL, Israel C. *Volcanoes of North America.* 346 pp. (Macmillan Co., New York, 1897.) The author calls his book "a reading lesson for students of geography and geology" but it is more than that. It is a very readable account of some of our own volcanic mountains, which are already familiar to most Americans but which gain added interest through comparison with the volcanoes of other countries and through discussion of the agencies which built them.

No subject in all the range of man's interests is more commonly used in introducing friendly conversation and in maintaining it than the weather. Well-told information about the atmosphere and the causes of meteorological phenomena, such as is contained in the books listed below, cannot fail to add to its interest.

HARRINGTON, Mark W. *About the weather.* 246 pp. (D. Appleton and Co., New York, 1899.) Attractively written. Antedates many interesting discoveries, but otherwise is one of the best of the popular works on meteorology.

DICKSON, H. N. *Climate and weather.* 256 pp. (Williams and Norgate, London, 1911.) Brief sketches on special topics, interestingly done.

LEMPFERT, R. G. K. *Weather science.* 94 pp. (T. C. and E. C. Jack, London, 1912.) Chiefly a very brief popular account of weather forecasting.

WARD, R. de C. *Climate, considered especially in relation to Man.* Second edition. (G. P. Putnam's Sons, New York, 1918.) The best book on climate addressed to the general reader.

TALMAN, C. F. *Realm of the air.* (P. F. Collier and Son, 1921.) Interesting, accurate and up-to-date.

Besides being blanketed with a layer of air, which is the domain of meteorology and "the weather," the Earth is also covered in large part with a thin layer of water, from a few inches to several miles deep—the ocean The geography of the ocean, the science which treats of the distribution, the physical properties, and the tides and currents of the ocean is known as oceanography.

MURRAY, John *The ocean* 256 pp (Henry Holt & Co, New York, about 1913) An interesting, non-technical, yet thoroughly reliable account of the methods, instruments and results relative to the depths, temperatures, physical properties, tides, currents and plant and animal life in the ocean.

The structural units of the solid earth—the "bricks" of which it is built—are the rocks, whose composition, properties, and origin form the subject matter of petrology

COLE, Grenville A J *Rocks and their origins* 175 pp Cambridge Manuals of Science and Literature. (Cambridge University Press, England, 1912) Neither abstruse nor popular, but adapted to a well-informed reader rather than a beginner The treatment is unbiased and thoroughly scientific, and covers the whole field, though briefly It is logical, thorough, accurate, and stimulating, readable, but not catchy There is no other book in the field of just the same sort, for comparison.

The constituent crystals or particles which make up the rocks (including the valuable ores) form the subject of "mineralogy"— from one point of view a branch of chemistry

BENNETT, Lee F. *Rocks and minerals* Third edition. 88 pp (Bogarte Book Co, Valparaiso, Indiana, 1914) An excellent little elementary book, describing in an interesting way 40 minerals and 40 rocks Suited to give the general reader with a minimum of time at his disposal a good idea of the scope of the sciences of mineralogy and petrology.

GRATACAP, Louis P. *A popular guide to minerals* 330 pp (D Van Nostrand Co, New York, 1912.) A splendidly illustrated work, based on the collections in the American Museum of Natural History in New York City The text is not up to the standard of the plates, being rather clumsily put together, although reasonably accurate and elementary in most places. Will appeal to the users of books who gain more from illustrations than from text matter.

The oldest of the sciences, and still the one with the most permanent popular appeal, notwithstanding the fact that its 5000-year competitor from the field of superstition—astrology—is still active, is astronomy:

ABBOT, Charles G *The sun* 448 pp (D Appleton and Co, 1911). The best book on the subject of the Sun, readable, though technical in places.

BALL, Robert S. *The story of the heavens* 556 pp (Cassell and Co., London, 1892) Delightfully written, and in popular language.

DYSON, F W. *Astronomy.* 247 pp (E P. Dutton and Co, New York, 1918) Elementary, yet thoroughly reliable.

HALE, George E. *The study of stellar evolution.* 252 pp. (University of Chicago Press, 1908) An interesting, well illustrated, and authoritative summary of results relating to the constitution of the stars and the Sun.

LEWIS, Isabel M. *Splendors of the sky.* 343 pp (Duffield and Co, 1920.) Popular, accurate, and up-to-date.

MCKREADY, Kelvin. *A beginner's star book.* 148 pp. (G. P. Putnam's Sons, 1912.) Many fine illustrations

TURNER, H. H. *A voyage through space.* (Society for Promoting Christian Knowledge, London, 1915) Pleasingly written and reliable

The Adolfo Stahl lectures in astronomy. 257 pp. (Stanford University Press, California, 1919.) Twelve lectures on modern astronomy by members of the Mount Wilson and Lick Observatory staffs Accurate, interesting, and nontechnical.

The properties of matter without regard to its particular form make the subject matter of physics and chemistry The carbon in a star has the same interest to the chemist and the physicist as the carbon in a tree-trunk or in a diamond But it is impossible to write a definition that will divide physics from chemistry and still include under each all that we commonly understand by the two terms In a general way, the chemist is interested in the composition of things, the physicist in their qualities The titles of a few chemical books follow [5]

SLOSSON, E E *Creative chemistry* 311 pp (Century Co, New York, 1920) A very interesting and readable book, showing particularly the important place of chemistry in modern industry and in warfare It is a book *about* chemistry and what it can do, rather than a book *of* chemistry, but can be recommended to the general and technical reader alike.

HENDRICK, Ellwood. *Everyman's chemistry* 374 pp (Harper and Bros, New York, 1917) This book is specifically "designed for those who declare that they do not know anything about the subject"

DUNCAN, Robert Kennedy. *The chemistry of commerce.* 263 pp. (Harper and Brothers, New York, 1907) An interesting interpretation of various phases of modern industrial chemistry.

MARTIN, Geoffrey. *Modern chemistry and its wonders* 358 pp (D. Van Nostrand Co, New York, 1915) A description in non-technical language of some of the striking modern advances in chemistry.

Although the chemist has made contributions to almost every other portion of the field of science, it remains unfortunately true that most of his books are written for specialists and not for the general reader The "physico-chemical" and "physical" portions of the field of physics and chemistry are not quite so lacking in readable books, the titles of some of these follow:

SODDY, Frederick. *Matter and energy.* 255 pp (Henry Holt and Co., New York, 1912) This is one of the best available accounts of fundamental physical and chemical principles. It is very brief and comprehensive, yet authoritative.

[5] Acknowledgments are due to the American Chemical Society's committee on chemical reading courses, of which W. A HAMOR is chairman This committee has published a full and well annotated list of books in all branches of chemistry See Journ Ind. Eng Chem. 12: 701, 800. 1920.

TYNDALL, John. *Fragments of science.* Fifth edition. 589 pp. (D. Appleton and Co., New York, 1884.) Though now fifty years old, these spirited essays by the most ardent proponent of the scientific method remain essentially correct and only the more firmly established by the later progress which has amplified our knowledge in the variety of fields touched upon.

EINSTEIN, Albert. *Relativity.* Translation by R. Lawson. 168 pp. (Methuen, London, 1920.) As simple an account as is readily possible of the old and new theories of relativity by the originator and leader of this revolutionary school of thought.[6]

WHETHAM, W. C. D. *The recent development of physical science.* 347 pp. (Blakiston's Son and Co., Philadelphia, 1909.) One of the Cambridge school of physicists tells of the work on the borderland of physics and chemistry during the important period to which he and his colleagues made valuable contributions.

AMES, Joseph S. *The constitution of matter.* 242 pp. (Houghton, Mifflin and Co., Boston, 1913.) Professor Ames' long and varied experience and his close association with developments of modern physics enabled him to produce this valuable book, which combines comprehensiveness in subject matter with simplicity of expression

FLEMING, J. A. *Waves and ripples in water, air, and aether.* 299 pp. (Society for Promoting Christian Knowledge, London, 1902.) This book is old but much of the field which it covers has not changed in recent years. It represents a course of Christmas lectures delivered to a "juvenile audience" at the Royal Institution, London. It is a most readable, instructive, and delightful book.

PERRY, John. *Spinning tops.* 136 pp. (Society for Promoting Christian Knowledge, London, 1901) This popular lecture stimulates the imagination by illustrating both the wealth of interesting phenomena connected with a commonplace toy and the elegant simplicity with which the science of mechanics unifies these effects.

MILLER, Dayton C. *The science of musical sounds.* 286 pp. (Macmillan Co., New York, 1916.) This book, written by one of the foremost authorities in America, is very readable and particularly strong on the experimental side.

BRAGG, William. *The world of sound.* 203 pp. (Bell and Co., London, 1920.) A very well done and up-to-date treatment of a branch of physics that appeals to everyone. The material was prepared for a juvenile audience, the most difficult of all audiences to write for.[7]

MICHELSON, A. A. *Light waves and their uses.* 166 pp. (University of Chicago Press, 1903.) This is a readable popular account of the applications of light waves to the most delicate and refined scientific measurements. The author is a universally recognized leader in this field of science and the examples which he quotes of the conquest by the human mind of the realm of the "infinitely little" are (although he does not say so) in large part the result of his own efforts.

[6] This book does not fully fit the specifications in the early paragraphs of this list, but neither does any other of the flood of books and essays on relativity The reader is not likely to be any better off for having read "Einstein made easy" before reading Einstein himself.

[7] Agassiz required of his students in each department of study "first a monograph, second a scientific lecture, third a popular lecture, fourth, a simple child's tale." SHALER, *Autobiography* (1909), p. 103.

ABNEY, W. de W. *Colour measurement and mixture.* 207 pp. (Society for Promoting Christian Knowledge, London, 1891.) In spite of the age of this book, the subject is one which has not suffered as much change as most of the branches of physics, and the book, which deals with the principles and measurements underlying color sensation, is well worth reading at the present time.

BOYS, C. V. *Soap bubbles. their colours and the forces which mould them.* 190 pp. (Society for Promoting Christian Knowledge, London, 1920.) This book, written by a man noted for his skill in devising experiments, contains a very interesting account of the properties of soap bubbles, and describes a large number of interesting experiments which may be made with them. (See also his companion book *Splash of the drop.*)

SODDY, Frederick. *The interpretation of radium.* 284 pp. (G P. Putnam's Sons, New York, 1912.) A readable non-technical account of the subject by one of the pioneers in this field.

Mathematics is not ordinarily considered a subject to arouse popular enthusiasm, yet it is full of human interest and is a constantly growing and developing science. The following books will give an insight into its variety and interest:

CONANT, Levi Leonard. *The number concept, its origin and development.* 218 pp. (Macmillan Co., New York, 1896.) An interesting and readable account of the probable origin and nature of the concept of number, with a description of number systems, past and present, among different races of mankind.

WHITEHEAD, A. N. *Introduction to mathematics.* 256 pp. (Home University Library, Henry Holt and Co., New York, 1911.) A brief survey of the principal topics treated of by mathematics, handled in a popular way.

YOUNG, John Wesley. *Lectures on the fundamental concepts of algebra and geometry.* (Macmillan Co., New York, 1911.) An excellent elementary treatment of the subject.

SHAW, James Byrnie. *Lectures on the philosophy of mathematics.* 206 pp. (Open Court Publishing Co., Chicago, 1918.) An unexcelled elementary survey of the entire field of mathematics, including content, principles, methods, significance, and nature of mathematics, with references to literature. Although the treatment is popular and readable, a considerable knowledge of mathematics is required for a full appreciation of this work.

DE MORGAN, Augustus. *On the study and difficulties of mathematics.* 288 pp. (Open Court Publishing Co., Chicago, 1902.) A classic.

A wealth of material is at hand in the history of science from which the following are selected, though the choice of only a few is difficult:

LIBBY, Walter. *An introduction to the history of science.* 288 pp. (Houghton Mifflin and Co., Boston, 1917.) Well-written essays on a few selected topics of the history of science. Perhaps the best elementary introduction to the subject.

SEDGWICK, W. T., and TYLER, H. W. *A short history of science.* 474 pp. (Macmillan Co., New York, 1917) The most comprehensive, if not the most accurate, elementary English book on the subject.

WHITE, Andrew D. *A history of the warfare of science with theology in Christendom.* 2 volumes. 415 and 474 pp. (D. Appleton and Co, New

York, 1896) An excellent book treating a delicate subject with tolerance, kindness and wisdom.

SMITH, David Eugene. *Number stories of long ago.* 136 pp. (Ginn and Co, Boston, 1919.) Stories on the history of arithmetic written for *children.* Accurate and entertaining. Probably the only book on the history of science which was written especially for children.

BERRY, Arthur. *A short history of astronomy.* 440 pp. (Charles Scribner's Sons, New York, 1910) Apparently there is no difference between this edition and a previous one published in London in 1898 Perhaps the best general elementary textbook. A very good introduction to the subject.

THORPE, Edward. *History of chemistry.* 2 volumes, 185 and 190 pp. (G. P. Putnam's Sons, New York, 1909–10.) Less complete but more elementary and far more easy to read than Ernst von Meyer's standard book.

GEIKIE, Archibald. *The founders of geology.* 289 pp (Macmillan and Co., London, 1897) The book embodies a series of lectures delivered by this distinguished English geologist before students of Johns Hopkins University. It is a charmingly written account of the beginnings of geological science and of the principal workers in that subject down to the latter half of the nineteenth century. Only European and British geologists are considered. The book is intended for the mature reader who knows something of geology, but it may be enjoyed as well by those who have no technical knowledge of the subject

MERRILL, George P. *Contributions to the history of American geology.* 546 pp. Part of Report of U S National Museum for 1904 (Washington, 1906) An interestingly written series of sketches of the leaders in American geology since its earliest days, well illustrated, and enlivened with anecdotes and comments. (A new edition is in preparation)

LOCY, William A. *Biology and its makers* 477 pp Third edition, revised. (Henry Holt and Co., New York, 1915.) Good introduction; simple, clear and entertaining.

PHYSICS.—*The wave lengths of X-rays* [1] RALPH W. G WYCKOFF, Geophysical Laboratory, Carnegie Institution of Washington. (Communicated by Arthur L. Day)

It is commonly assumed that the length of X-rays has been uniquely and definitely determined from the study of the structures of crystals. In the following discussion it will be shown, taking the case of sodium chloride as an example, that with the *existing* knowledge it is impossible to determine definitely the structure of any crystal in advance of a knowledge of the wave length of X-rays. Viewed then from this position only, the problem of the length of X-ray waves and of the structures of crystals becomes indeterminate and recourse must be had to other sources of information.

The customary method of determining the wave length of X-rays.—The wave length of X-rays has been determined through the following course of reasoning.[2] If a crystal is considered as composed of a

[1] Received June 16, 1921.

[2] W H. and W L. BRAGG. *X-rays and crystal structure.* (London, 1918.)

regular and orderly repetition of a certain grouping of atoms throughout space (as seems entirely permissible), and if we assume the correctness of the Laue theory[3] that the atoms in this crystal act as diffracting centers of a three-dimensional diffraction grating, then it follows that the wave length of the X-rays diffracted by this crystal, the "spacing between like planes" in the direction of the diffraction, and the angle of the diffraction effect are connected by the familiar expression

$$n\lambda = 2d \sin \theta \qquad (1)$$

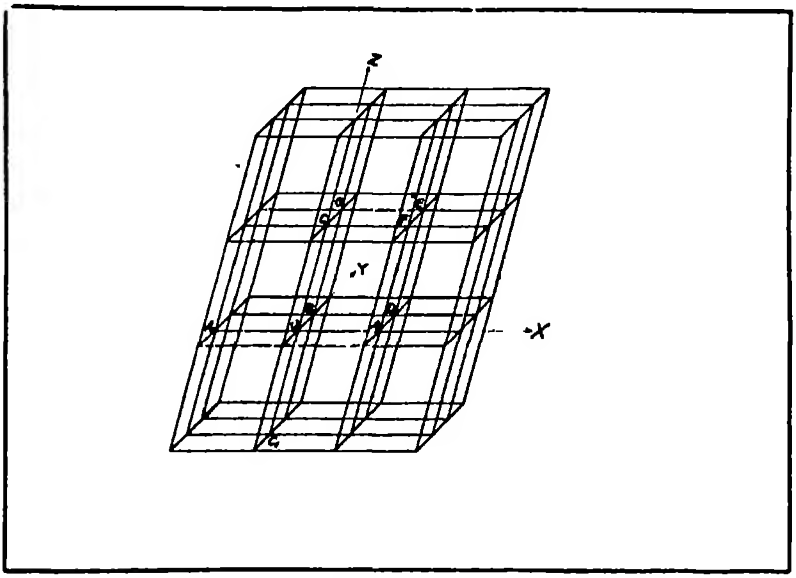

Fig 1

where n is the "order" of the reflection,

λ is the wave length of the diffracted X-rays,

d is the "spacing," that is, the distance between like planes in the chosen direction, and

θ is the angle of the diffraction.

In figure 1 *ADEFCGBO* represents the unit cell which is repeated along the axes of coordinates in a cubic crystal. The length of the side of this unit cube, *AO*, is d_{100}, the "spacing" against the cube face. The volume of this unit is then

$$V = (d_{100})^3 = \frac{mM}{\rho} \qquad (2)$$

where M is the weight of one chemical molecule of the substance,

[3] M. LAUE. Ann. Phys. 41: 971. 1913.

m is the number of these molecules in the unit,
ρ is the density of the crystal, and
V is the volume of the unit.

In this expression the density is known and the value of M is simply the molecular weight of the salt multiplied by the weight of an atom of hydrogen, which has been shown to be close to 1.64×10^{-24} grams. The other term upon the right hand side of this equation, m, can be known, however, only when the crystal structure of the salt is also known

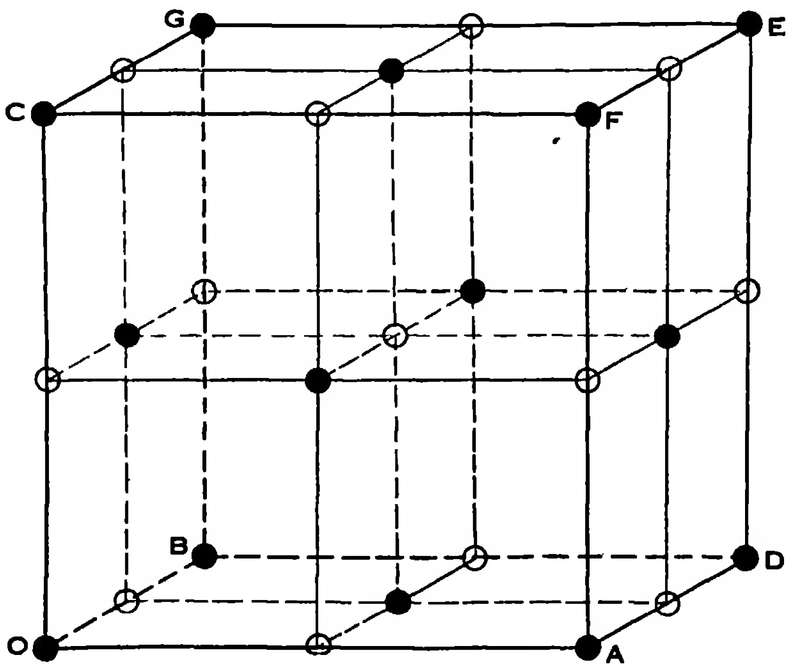

Fig 2

In first studying the wave lengths of X-rays the alkali halides were investigated, and of these the one which is from all points of view the most satisfactory to treat is sodium chloride. Since no information immediately useful for the present purpose can be obtained from a consideration of any other available crystals, it will be permissible to limit attention to this one salt.

The only data for establishing the structure of sodium chloride which are truly independent of assumptions more or less tacitly based upon an imagined structure of some crystal are (1) the observation (from Laue photographs) that only planes all of whose indices are odd are

found to give effects in what must correspond with the first order region, and (2) the confirmatory observation (from spectrometer measurements) that the first observable reflections from the (100), (110) and (111) faces stand in the ratio of

$$1 : \frac{1}{\sqrt{2}} : \frac{2}{\sqrt{3}}$$

The familiar "sodium chloride arrangement" (Fig. 2), with four chemical molecules associated with the unit cell, is in agreement with the above data, so that it has been taken as the structure of this crystal. Accepting such an identification as correct, a substitution of $m = 4$ in expression (2) yields d_{100}, and since the value of n is also directly determinable from a knowledge of the crystal structure, it is but a step to obtain the wave length of the X-rays (diffracted through the angle θ).

Other possible structures for sodium chloride.—The most serious objection to this determination of the wave length of X-rays obviously rests in the implied statement that because it agrees with these rather meager data, the "sodium chloride arrangement" is the correct one for this salt.

It will now be shown that other structures are possible. The effect of this observation will of course be to render this determination of the wave length of X-rays based upon the study of the structure of a crystal indeterminate (and along with it all determinations of the structures of crystals).

A factor which gives the effect of phase differences between the waves scattered by the atoms in any arrangement and which is therefore proportional, under certain conditions, to the intensity of the X-rays seemingly "reflected" by a plane of atoms can be written as[4]

$$I \propto \sum_m [\rho_m \cos 2\pi n\,(hx_m + ky_m + lz_m)]^2 + \sum_m]\rho_m \sin 2\pi n\,(hx_m + ky_m + lz_m)]^2,$$

where I is the intensity of reflection from planes hkl having the same relative spacings,

ρ is the scattering power of the atom m whose coordinate position is $x_m y_m z_m$, and

n is the order of the reflection.

[4] RALPH W. G. WYCKOFF. Amer. Journ. Sci. 50: 317. 1920.

The summation is to be taken over each atom in the unit cell. The spacings between like planes in a simple cubic lattice (Fig. 1) is proportional to

$$\frac{1}{\sqrt{h^2+k^2+l^2}} \tag{1}$$

where h, k, and l are the indices of the plane.

With the aid of these two expressions, and *without* any precise knowledge of the "laws" of scattering, it is possible to determine the ratio of the spacings between like planes to be observed from any arrangement of atoms.

Every such structure which possesses complete (holohedral) cubic symmetry must be either a general or a special case of one of the ten space groups O_h^{1-10} The ratio of the spacings to be observed from each of these space groupings for the (100), (110) and (111) planes has been calculated [5] Of these ten groups but one, O_h^5, shows the sequence observed for sodium chloride Any number of conceivable structures for sodium chloride can be developed from this space group by simply assigning different coordinate values to the positions of the sodium and chlorine atoms, and except for very special values of these coordinates the ratio of the spacing from the three planes under discussion will always be the same as that experimentally observed for sodium chloride.[6] For the sake of simplicity of illustration the least complicated of the special cases of this space group will be treated. The three special cases containing the fewest number of molecules within the unit cell are [7]

Four equivalent positions:

(1) 000; $\frac{1}{2}\frac{1}{2}0$; $\frac{1}{2}0\frac{1}{2}$; $0\frac{1}{2}\frac{1}{2}$.

(2) $\frac{1}{2}\frac{1}{2}\frac{1}{2}$; $00\frac{1}{2}$; $0\frac{1}{2}0$; $\frac{1}{2}00$.

Twenty-four equivalent positions:

(3) $u00;\ u+\frac{1}{2},\frac{1}{2},0,\ u+\frac{1}{2},0,\frac{1}{2};\ u\frac{1}{2}\frac{1}{2};$

$\bar{u}00,\ \frac{1}{2}-u,\frac{1}{2},0,\ \frac{1}{2}-u,0,\frac{1}{2};\ \bar{u}\frac{1}{2}\frac{1}{2};$

$0u0,\ \frac{1}{2},u+\frac{1}{2},0,\ 0,u+\frac{1}{2},\frac{1}{2},\ \frac{1}{2}u\frac{1}{2};$

$0\bar{u}0,\ \frac{1}{2},\frac{1}{2}-u,0,\ 0,\frac{1}{2}-u,\frac{1}{2},\ \frac{1}{2}\bar{u}\frac{1}{2},$

$00u;\ \frac{1}{2},0,u+\frac{1}{2},\ 0,\frac{1}{2},u+\frac{1}{2};\ \frac{1}{2}\frac{1}{2}u;$

$00\bar{u};\ \frac{1}{2},0,\frac{1}{2}-u;\ 0,\frac{1}{2},\frac{1}{2}-u,\ \frac{1}{2}\frac{1}{2}\bar{u}.$

[5] P. NIGGLI. *Geometrische Krystallographie des Discontinuums*, p. 492

[6] In the general case there are 192 equivalent positions within the unit cell of this group so that there may be as many as 192 molecules of sodium chloride within it.

[7] These results are taken from a book now being prepared for publication which contains an analytical expression of all of the special cases of each of the space groups.

Placing sodium and chlorine (or chlorine and sodium) atoms at the positions of (1) and (2) yields the "sodium chloride arrangement." The next simplest structure that can be developed is obtained from arrangement (3) by placing atoms of sodium at the 24 points corresponding to a value of $u = u_1$ and chlorine atoms at the points where $u = u_2$.

For such a structure the intensity of a reflection from a plane whose indices are h, k and l is proportional to (compare equation (1)).

$$I \propto A^2 + B^2,$$

$$\begin{aligned} A = \rho_{\mathrm{Na}}\,[&2\cos 2\pi n h u_1 + 2\cos 2\pi n k u_1 + 2\cos 2\pi n l u_1 + \\ &\cos\pi n(2hu_1 + h + k) + \cos\pi n(h - hu_1 + k) + \cos\pi n\,(h + 2ku_1 + h) + \\ &\cos\pi n(h + k - 2ku_1) + \cos\pi n(h + k + 2lu_1) + \cos\pi n\,(h + k - 2lu_1) + \\ &\cos\pi n(2hu_1 + k + l) + \cos\pi n(h - 2hu_1 + l) + \cos\pi n\,(h + 2ku_1 + l) + \\ &\cos\pi n(h - 2ku_1 + l) + \cos\pi n(h + 2lu_1 + l) + \cos\pi n\,(h + l - 2lu_1) + \\ &\cos\pi n(2hu_1 + k + l) + \cos\pi n(k + l - 2hu_1) + \cos\pi n(2ku_1 + k + l) + \\ &\cos\pi n(k - 2ku_1 + l) + \cos\pi n(k + 2lu_1 + l) + \cos\pi n\,(k + l - 2lu_1)] + \\ &\rho_{\mathrm{Cl}}[\text{a similar set of terms involving } u_2] \end{aligned}$$

The B term, a similar sine expression, is not in this instance qualitatively important When h, k and l are two odd and one even ($h = 2m + 1$, $k = 2p + 1$, $l = 2q$, where m, and p and q are any integers) or when they are two even and one odd ($h = 2m + 1$, $k = 2p$, $l = 2q$) this expression is invariably equal to zero for $n = 1$ When, however, the indices are all odd, the intensity becomes

$$A = 8\cos 2\pi u\,(2m + 1) + 8\cos 2\pi u\,(2p + 1) + 8\cos 2\pi u\,(2q + 1),$$

for $n = 1$ Except perhaps for very special values of u_1 and u_2, this expression will invariably have a value other than zero In case $n = 2$ all three types of planes will give factors of appreciable value This arrangement is consequently in entire agreement with the data *that we now possess*[8] upon which to base the *first* determination of the structure of a crystal [9]

[8] This need be no longer true if we possessed accurate measurements of the relative intensities of the X-rays reflected from different planes of this type, *combined with* a knowledge of the positions of the electrons as the scattering centers within the atom

[9] The agreement with the spectrometer experiments is readily shown By substituting the appropriate values for h, k and l in expression (1), the ratio of the spacings for the (100), (110) and (111) planes in the cubic lattice is seen to be $1 \; \frac{1}{\sqrt{2}} \; \frac{1}{\sqrt{3}}$ Since the calculations given above have shown that the first order reflections from the first two of these planes is blotted out, the first observable reflections would occur at twice the angle of the first reflection and would consequently give apparent spacings of

$$\frac{1}{2} \quad \frac{1}{2\sqrt{2}} \quad \frac{1}{\sqrt{3}} \text{ or } 1 : \frac{1}{\sqrt{2}} : \frac{2}{\sqrt{3}}$$

It will be sufficient for the present purpose to have pointed out a single structure for rock salt, besides the generally accepted one, which is in agreement with the experimental data. There are undoubtedly numerous others which would serve equally well. It is not, however, feasible to indicate even all of the different types of structures that would fulfill the present requirements. This arises in part from the fact that besides those other structures which can be developed from O_h^5, it is conceivable that such special values could be assigned to the coordinates of arrangements developed from other space groups that the intensity of the reflections from certain types of planes would be either obliterated entirely or would be so weak as to pass detection. As a result the sequence of spacings found for such an arrangement might agree with that for rock salt.[10,11]

The wave lengths of the X-rays calculated upon the basis of structures representing sodium chloride but possessing various numbers of molecules in the unit cell must of course differ from one another. For instance the wave lengths of the rays diffracted through the angle θ when calculated upon the assumption of the correctness of the sodium chloride structure and when calculated upon the assumption of the structure just considered which has twenty-four chemical molecules within the unit cell will stand in the ratio of $\sqrt[3]{4}$ to $\sqrt[3]{24}$.

Quantum calculations of the wave lengths of X-rays.—It was early pointed out that the quantum hypothesis furnishes an independent way of obtaining the wave lengths of X-rays By identifying the energy of the electrons required to excite either the characteristic X-rays[12] or those of the short wave length limit of the continuous spectrum[13] (as the case may be) with the energy of the rays that are produced, it is possible from the quantum relationship

$$E = nh\nu$$

to get the frequency (ν) and hence the wave length of the corresponding X-rays.[14] If it is assumed that such X-rays correspond with the

[10] This sort of agreement with experiment is illustrated in the course of the treatment of the structure of magnesium oxide RALPH W. G. WYCKOFF. Amer. Journ Sci 1: 138. 1921 (See the grouping there called (*j*))

[11] In the light of present knowledge such a structure as we have just discussed need not be immediately disregarded as impracticably complicated, especially when it is borne in mind that it offers the chance of so placing a sodium and a chlorine atom nearer to one another than to other atoms as to preserve, in the existence of a chemical molecule, the older idea of the nature of solid sodium chloride.

[12] W. H and W L. BRAGG, *op cit*, p 72

[13] W. DUANE and F. S. HUNT. Phys Rev (2) 6: 166 1915, etc.

[14] W. DUANE and F. S HUNT, *op. cit.*

expenditure of a single quantum of energy ($n = 1$), as would seem probable, then the resulting wave length is in agreement with that calculated from the "sodium chloride arrangement."

The fact that it is not possible at the present time to obtain the structure of any crystal with surety without at the same time knowing the wave lengths of X-rays would consequently make it seem more logical to think of our determination of the wave lengths of X-rays (and with it all of our studies of the arrangement of the atoms in crystals) as based directly upon this quantum hypothesis, to stand or to fall with it.

Of course even this determination of the wave length of X-rays is not entirely satisfactory. For instance if, for some reason, it should seem desirable to suppose that the expenditure of two quanta of energy were required to excite X-rays, then we should have a value of the wave lengths corresponding to a structure for sodium chloride having thirty-two chemical molecules associated with the unit Furthermore the extension of the quantum relationship from the range of light radiation to that of X-rays was indeed a large extrapolation. In spite of this, the most persuasive evidence that a satisfactory determination has been obtained is to be found in the fact that the application of the quantum relation to the limit of the continuous radiation[15] yields values for wave lengths which are in such close accord with a reasonable determination of crystal structure. This structure *happens to be* the "sodium chloride arrangement" (in the case of sodium chloride).

SUMMARY

Taking the case of sodium chloride as typical, it is shown that there are other structures besides the commonly accepted "sodium chloride arrangement" which are in agreement with the *present* experimental data. As a result of this lack of definiteness it is emphasized that it is more logical to consider the value of the wave lengths of X-rays as based upon the quantum hypothesis.

[15] E, the energy, can be obtained from a knowledge of the voltage required to produce X-rays of the frequency ν and of the charge (e) on the electron, h is the universal constant of Planck; and n is an integer.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue.

OPTICS.—*Dispersion in optical glasses: II.* FRED E. WRIGHT. Journ. Opt. Soc. Amer. **4:** 195–204 1920. (Geophysical Lab. Papers on Optical Glass, No. 29)

In this paper proof is given that, because of the relatively short range of the visible spectrum, the substitution in a dispersion formula of the reciprocal of the refractive index, or of the excess refractivity, or by analogy of other functions of the refractive index for the direct values, leads to dispersion formulas which are fairly satisfactory. Thus, if in the two-constant Cauchy formula, $n = A + B\ \lambda^{-2}$ or $n - 1 = A' + B\ \lambda^{-2}$, the reciprocal of the refractive index or of the excess refractivity be written· $n^{-1} = C' + D\ \lambda^{-2}$ or $(n - 1)^{-1} = C + D\ \lambda^{-2}$, the new equations represent rectangular hyperbolas in case λ^{-2} is considered to be the independent variable. The last equation was recently suggested as a substitute for the Hartmann dispersion formula. A series of computations demonstrates, however, that for the crown-glasses this equation is less satisfactory than the Cauchy formula, while for the flint-glasses none of the foregoing equations is especially good. The last equation is, moreover, always less satisfactory than the Cauchy formula for computation purposes. The usefulness of the last equation appears, therefore, to be limited and less satisfactory for general application than the two-constant Cauchy formula.

F. E W.

GEODESY. *Modern methods for measuring the intensity of gravity* CLARENCE H. SWICK U. S. Coast and Geodetic Survey Special Pub. **69.** Pp. 96, figs 26 1921

The measurement of gravity on land by the U S. Coast and Geodetic Survey is made with an accuracy of about 2 or 3 parts in a million Such accuracy with a field instrument requires more than ordinary care and skill on the part of the observer. At the present time all gravity measurements are made with pendulums only a quarter of a meter in virtual length, which are placed in an air-tight receiver and swung under a pressure of about 1/15 of an atmosphere The cost and time required for a determination are very much less than they were and the results obtained are far more accurate than with the old types of apparatus

This publication is primarily a working manual for field and office use. Aside from one chapter of historical data the entire book is given over to a detailed description of the instruments and to instructions for making the observations and computations All the necessary formulas and tables are included. Sample records are shown and a sample computation for one station is carried through all the required steps.

INORGANIC CHEMISTRY.—*The binary system åkermanite-gehlenite.* J. B FERGUSON and A. F. BUDDINGTON. Amer. Journ. Sci **50:** 131-40. 1920.

The binary system åkermanite (2CaO.MgO.2SiO)-gehlenite ($2CaO.Al_2O_3$-SiO_2) was studied by the quenching method and the solidus and liquidus curves were determined. The system forms a complete series of solid solutions with a minimum melting-point about 70° below the melting-point

of åkermanite, the component of lower melting-point, at a composition of about 74 per cent åkermanite and 26 per cent gehlenite.

The densities of crystals and glasses of åkermanite, gehlenite, and several intermediate mixtures were determined and found to confirm the isomorphous character of the system. Åkermanite was found to show the unusual feature of its glass having a greater density than the corresponding crystals at 25° C. This peculiar character is checked by the indices of refraction for glass and crystal, respectively, the index of refraction of the glass being greater than the maximum index of the crystal.

The optical characters of the crystals are a continuous function of the composition. In optical characters åkermanite is positive and gehlenite is negative. Crystals of certain intermediate compositions are isotropic for light of a definite wave length and constitute a transition phase between positive and negative crystals. J. B F

GEOLOGY.—*Mining in the Matanuska coal field and the Willow Creek district, Alaska.* THEODORE CHAPIN U. S. Geol. Survey Bull **712-E.** Pp. 46(131–76). 1920

This report describes developments in the Matanuska coal field up to the end of 1918 and records some recently acquired knowledge of the structure and stratigraphy of the coal-bearing rocks and the character and persistence of the coal beds, details of which are becoming more apparent with the opening of the underground workings. The areal distribution, character, chemical analysis, steaming and coking quality of the coal are discussed, stratigraphy and structure of the region are described, and the mining developments depicted. R. W. STONE

GEOLOGY.—*Mining in northwestern Alaska.* S. H. CATHCART. U. S. Geol. Survey Bull. **712-G.** Pp. 14(185–98). 1920.

Discusses the adverse conditions which caused greatly decreased mineral production in Seward Peninsula in 1918; describes the use of cold water in thawing perpetually frozen muck and gravel and its application to placer mining. Tungsten and platinum were produced, but wholly incident to the mining of placer gold. A small quantity of coal was mined, and drilling for oil in a locality where the hard rocks are granite and schist was unsuccessful. R. W. STONE.

GEOLOGY.—*The Mogollon district, New Mexico* HENRY G. FERGUSON. U. S. Geol Survey Bull. **715-L.** Pp. 34(171–204). 1921.

The Mogollon or Cooney district is in the southwestern part of Socorro County, New Mexico, about 14 miles from the Arizona line. The rocks of the district are nearly all lavas, or sedimentary rocks composed of materials derived from lavas. Flows of rhyolite and andesite, together with sedimentary and pyroclastic rocks, had reached a total thickness of several thousand feet when faulting of considerable magnitude took place and the region was broken up into irregular blocks bounded by normal faults. The faulting was closely followed by the introduction of mineral-bearing solutions, which followed channels determined by the previous faulting, so that practically all the faults are the sites of veins.

The ores of the district are valuable mainly for silver. Argentite, pyrite, bornite, chalcopyrite, and tetrahedrite, together with small amounts of horn silver and native silver, are the principal ore minerals. The ores are principally sulfides and give evidence of being in part due to enrichment, although

the relative importance of secondary processes has not yet been fully determined. R. W. STONE.

GEOLOGY.—*Potash resources of Nebraska*. W. B. HICKS. U. S. Geol. Survey Bull. 715-I. Pp. 15(125–39). 1921.

Describes the location, area, and probable potash content of the alkali lakes in the sand-hill region of Nebraska, and discusses the composition of the brine and origin of the potash. R. W. STONE.

GEOLOGY.—*Mineral resources of the Goodnews Bay region, Alaska*. GEORGE L. HARRINGTON. U. S. Geol. Survey Bull. 714-E. Pp. 22(207–28). 1921.

The Goodnews Bay region as here considered embraces the territory lying south of Arolic River and draining into Kuskokwim Bay, Alaska. In many respects this region is one of the most inaccessible in Alaska for a small expedition. For a number of years it has been necessary to come overland from the Yukon either by the portage or by way of Iditarod, or to travel in a kayak or canoe, or by small schooner or sailing boat from Togiak.

The sedimentary rocks comprise limestone, argillite, sandstone, and conglomerate, and the metamorphosed equivalents of most of these. A considerable variety of igneous rocks is also found, including basalt flows, dikes that were taken in the field to be andesites, and intrusive granites, with some massive intrusives that are probably intermediate in composition between the granite and the basalt. A large part of the region is covered by unconsolidated deposits of alluvial, glacio-fluviatile, and marine origin.

Gold placer mining is the principal interest. The original deposition of the gold in fissures associated with quartz was probably genetically related to the intrusion of the late Mesozoic granites into the sedimentary and earlier igenous rocks, which range from Paleozoic to probably late Mesozoic in age. From the original deposits the gold has been eroded by streams and other agencies, not including glaciation, and has been concentrated in placers by some streams, mainly those in the vicinity of the granites. Glacial erosion has removed most of the gold-placer deposits and has scattered the gold widely over a considerable area in amounts not suitable for profitable mining

Postglacial concentration has been effected by some streams in connection with the erosion of the rocks containing auriferous veins. R. W. STONE.

GEOLOGY.—*Potash deposits in Spain*. H. S. GALE. U. S. Geol. Survey Bull. 715-A. Pp. 16, pls. 3, figs. 3. 1920.

Potash was discovered in Spain in 1912, during an attempt to open a salt mine near Suria, Province of Barcelona. Evidence gained in a shaft and several borings convinced local engineers that the deposits contain 200,000,000 tons of pure potash (K_2O), and in 1918 a mine shaft and a refining plant were begun. The shaft is located near the axis of an anticline, in a zone of intense folding, and the potash and associated salt beds are probably much contorted; such contortions are seen in the beds in the crest of the anticline at Cardona, 8 miles distant, where salt is extensively mined. The evidence of the existence of potash in the Cardona deposits, however, is not very definite, and information as to the occurrence in the surrounding region is meager. Many concessions for prospecting and exploitation in an area of 400 square miles have already been granted, and the Government has re-

served about 1800 square miles for future exploration. Restrictive legislation, as outlined in this paper, somewhat hampers activities in the district. The prospects indicate an output of potash ample for Spanish needs, but no judgment can yet be ventured as to the influence of the Spanish field on the world market. J. D. SEARS.

CERAMICS.—*Note on the motion of the stirrers used in optical-glass manufacture.* E. D. WILLIAMSON and L. H. ADAMS. Journ. Amer. Ceramic Soc. 3: 671-677. 1920. (Geophysical Lab. Papers on Optical Glass, No. 25.)

Perhaps the most noticeable difference between the manufacture of optical glass and that of other types of glass (bottle, window, and plate) is that the melt must be stirred vigorously in order to get complete mixing. The reason behind this necessity is the close approach to homogeneity specified in the tests to be passed by the finished article. The stirrers used are necessarily of a very simple nature, generally consisting of a clay rod attached at right angles to an iron water-cooled pole, the other end of which is driven at steady speed in a horizontal circle, while supported near the center by a pulley or other support. Such a device does not cause circular motion of the stirring-rod, but causes it to describe an egg-shaped figure at a variable speed. A slightly more uniform motion is obtained if a pin attached to the pole slides in a fixed slot instead of the pole passing over the pulley, but the general results are not very different. If the support is not close to the center of the pole, the motion of the rod is far from circular and a large part of the glass in the pot is not stirred. E. D. W.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY

548TH MEETING

The 548th meeting of the Society was held at the United States National Museum on October 26, 1920, at 4 45 p.m. Dr. ALES HRDLICKA, curator of physical anthropology, U. S. National Museum, addressed the Society on *The anthropological problems of the Far East and the Pacific.* The lecture was carefully prepared and dealt with a subject with which Dr. Hrdlicka was most familiar both because of long study and recent field work. The paper was discussed by Mr. HOLMES, Mrs. ZELIA NUTTALL, Dr. MICHELSON, and Dr. SWANTON.

549TH MEETING

At the 549th meeting of the Society, held at the National Museum at 4 45 p.m. on November 16, 1920, Mr. SYLVANUS G. MORLEY, Associate of the Carnegie Institution of Washington, addressed the Society on *The hieroglyphic writing of the ancient Mayas.* Mr. Morley illustrated his excellent presentation with charcoal drawings of the glyphs. At the conclusion of Mr. Morley's lecture, Mr. W. E. GATES, of Baltimore, gave an interesting and enthusiastic talk of ten minutes on the subject of Maya writing, and told especially of recent progress which he has made in the deciphering of color symbols, to which Mr. Morley had referred in his talk.

550TH MEETING

The 550th meeting was held in the National Museum at 4.45 p.m. on December 14, 1920, and had as program an illustrated lecture by Mr. S. D. BULLOCK, of the Bureau of Plant Industry, Department of Agriculture, entitled *Ten years among the Araucanians of Chile*. Mr. Bullock has lived for ten years among the Araucanian Indians of the vicinity of Valdivia, Chile, as industrial teacher of the Indians, and knows them and their customs intimately. At the close of the lecture Mr. Bullock exhibited some Araucanian costumes and other objects. Questions were asked by Lieut. W. E. SAFFORD and others.

551ST MEETING

The 551st meeting was held at the National Museum at 4.45 p.m. on January 18, 1921 Mr. WILLIAM E. MYER, of Nashville, Tennessee, gave an interesting lecture on *Recent explorations in the Cumberland Valley, Tennessee*, being an account of archaeological field work done by him in 1920 for the Bureau of American Ethnology. The talk was illustrated by lantern slides. The lecture was discussed by Dr. FEWKES and others.

552D MEETING

The 552d meeting was held at the National Museum at 4 45 p m. on February 8, 1921. Lieut. W. E. SAFFORD, of the Department of Agriculture, spoke on *Old and new Samoa*. The lecture was illustrated by original slides. Lieut. Safford made his first visit to Samoa on the U. S. Ship *Mohican* in 1888, before Robert Louis Stevenson came to the islands, and made a second visit in 1899, two years after Stevenson's death. The lecturer spoke throughout from first-hand information At the close of the lecture there was a discussion by Dr. HOUGH, Mr. HOLMES, and others.

553D MEETING

At the 553d meeting, held at the National Museum at 4.45 p.m., March 21, 1921, Dr. J. WALTER FEWKES, Chief of the Bureau of American Ethnology, spoke on *The fire temple of the Cliff Dwellers*. The ruin of the Fire Temple was excavated by him in the Mesa Verde National Park, Colorado, during the summer of 1920 The lecture was beautifully illustrated by slides. It was discussed by Dr. HOUGH, Mr HOLMES, and others.

554TH MEETING

The program of the 554th meeting, held at the National Museum at 4.45 p.m., March 22, 1921, was a paper by Mr. G. N. COLLINS, of the Department of Agriculture, on *The origin and early distribution of maize*. Mr. Collins agrees on the whole with Harzberger, who advocated the theory that maize has been hybridized with some other close relative, but puts the relationship a little further off—for genetic reasons. The paper was discussed by Dr. HOUGH, Prof. HITCHCOCK, Lieut. SAFFORD, Mr. LA FLESCHE, and others.

555TH MEETING

The 555th meeting of the Society was held in conjunction with the Medical Society of the District of Columbia, at the new home of the latter at 1718 M Street, N. W., on April 5, 1921, at 8 00 p.m. Dr. GEORGE M. KOBER presented as address of the retiring president of the Anthropological Society of Washington, 1920, a paper entitled *A plea for the prevention of permanent disabilities in childhood*. In pursuance of the established custom of the Society, there was no discussion of this paper, it being a presidential address.

556TH MEETING

The 556th regular meeting (42nd annual meeting) of the Society was held at the National Museum at 4.45 p.m., April 19, 1921. Dr. C. HART MERRIAM, President of the Society, delivered a lecture on *The Indians of the Yosemite Region, California*. The lecture was illustrated by a large number of slides showing the distribution of the dialects of the stock, the history of the Indians, the landmarks of the region, and the present survivors. At the close of the lecture the annual meeting of the Society was held.

The Secretary, JOHN P. HARRINGTON, reported that the Society has at present 51 active members, 6 life members, 4 associate members, and 2 honorary members, making a total membership of 63. New members added during the year were: MR. W. E. MEYER, MR. M J. CAPLES, Mr. R. E. MONTGOMERY, and MISS ELLEN HAYES. One active member was lost through death: Dr. EDWIN LEE MORGAN. The Treasurer's report showed a balance to the credit of the Society of $139.56, and total assets of $667.47.

The following officers were reelected for the ensuing year: *President*, C. HART MERRIAM; *Vice President*, NEIL M. JUDD; *Secretary*, JOHN P. HARRINGTON; *Treasurer*, J. N. B. HEWITT; *Board of Managers*, CHARLES L. G. ANDERSON, FELIX NEUMANN, FRANCIS LA FLESCHE.

JOHN P. HARRINGTON, *Secretary*.

SCIENTIFIC NOTES AND NEWS

The topographic survey of the Virgin Islands was completed by the U S. Coast and Geodetic Survey in June.

An interdepartmental conference was held on July 25 at the Interior Department to discuss the status of patents arising within the government service. The purpose of the conference was to coordinate and formulate the views held in the various bureaus and departments on this subject. After discussion, a committee of five was appointed to report in detail ways and means for the suggested coordination, and another committee of three was appointed to develop a plan for a general clearing house of information for the departments with respect to licenses, shop rights, and titles in patents which the Government has acquired or may acquire.

Mr. WALTER G. CAMPBELL was appointed acting chief of the Bureau of Chemistry in August.

A geological party of four, consisting of Professors R. A. DALY and CHARLES PALACHE of Harvard University, Professor G. A. F. MOLENGRAAF of the University of Delft, Holland, and Dr. F. E. WRIGHT of the Geophysical Laboratory, Carnegie Institution of Washington, will spend the coming winter in southern Africa, in a geologic and petrologic study of the Bushfeld igneous complex in Transvaal.

Dr. H. C. DICKINSON, chief of the automotive investigations division of the Bureau of Standards, has been granted a leave of absence to become director of research for the Society of Automotive Engineers. He will continue to assist in the work of the Bureau in a consulting capacity.

Dr. GRAHAM EDGAR, professor of chemistry at the University of Virginia, has been associated with the Fixed Nitrogen Research Laboratory at the American University during the summer, completing some work which he began there during the War.

Major LOUIS ALBERT FISCHER, chief of the division of weights and measures of the Bureau of Standards, died on July 25, 1921, in his fifty-eighth year

Mr. Fischer was born in Washington, D. C., January 4, 1864. He was educated at George Washington University, and afterwards joined the staff of the U. S. Coast and Geodetic Survey, where he was in charge of the office of weights and measures, the forerunner of the present Bureau of Standards. He took an active part in the organization of the Bureau in 1901, and had been in charge of its special division on standards of length, volume, and mass since that date. He was a leader in the movement to promote uniform standards of weights and measures in the States and municipalities of the country He was a member of the ACADEMY, past president of the Philosophical Society, and chairman of the Washington Section of the American Society of Mechanical Engineers

Dr. F. E. MATTHES, of the U S. Geological Survey, has been spending the summer in exploration of the crest of the Sierra Nevada as far south as Kings River Canyon, in search of data on the earlier glaciation of the region.

Mr. J. D NORTHROP has been reinstated as geologist in the U. S. Geological Survey, and has been assigned to duty in the mineral division of the Land Classificat on Board.

Dr. T. OKADA, director of the recently established Imperial Marine Observatory at Kobe, Japan, visited the scientific institutions of Washington in August

Prof J. F. ROCK returned in June from an eleven months' exploring trip through remote parts of Siam, Burma, Assam, and Bengal for the U S. Department of Agriculture. He showed the Botanical Society on June 27 the first photographs ever exhibited of the tree, *Taraktogenos kurzii*, in its native habitat The seeds of this tree are the source of chaulmoogra oil, a remedy for leprosy, and Professor Rock secured enough of the seeds to assure the establishment of a plantation of the tree in Hawaii.

Dr J H. SHRADER, formerly with the Bureau of Chemistry, U S. Department of Agriculture, became director of the bureau of chemistry and food of the Health Department of Baltimore on July 1

Dr. GEORGE OTIS SMITH, director of the U S. Geological Survey, attended a meeting on July 20 in London as a member of the organization committee of the International Geologic Congress

Dr. W W. SKINNER, chief of the water and beverage laboratory of the Bureau of Chemistry, has been appointed assistant chief of the Bureau.

Mr. R. S. TOUR, chemical engineer of the Nitrate Division, Ordnance Department of the Army, has been appointed dean of the department of chemical engineering at the University of Cincinnati.

Dr. TSAI, chancellor of the National University of Peking, China, visited the scientific institutions of Washington in June.

Mr. ROSENDO VARGAS, a member of the Taos tribe of Indians of New Mexico, has been assisting Mr. J. P. HARRINGTON of the Bureau of Ethnology in the study of the ethnology of the tribe. Mr. Vargas is at present an employee of the office of Indian Affairs, Department of the Interior.

Mr. C. J. WEST has resigned as director of the information department of A. D. Little, Inc., of Cambridge, Massachusetts, to become managing editor of the Tables of Physical and Chemical Constants now being compiled under the joint auspices of the National Research Council, the American Chemical Society, and the American Physical Society.

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PHYSICS.—*A radioactive quantity requiring a name*[1] N. ERNEST DORSEY, Bureau of Standards.

The problems that are encountered in the quantitative study of radioactive materials and processes may be divided into two classes. In one class will be placed the strictly chemical problems; such as, the amount of the element that is contained in a ton of ore, the ratio of the amounts of different elements that are found associated, the atomic weights and the chemical properties of the several elements. In the other class will be placed the problems that are primarily concerned with radioactive phenomena; such as, the rate of transformation, the rate of emission of energy, the rate of production of alpha or of beta particles or of gamma pulses

In problems of the first class one is concerned with the total weight or with the total number of atoms present, and the amount of the element may appropriately be expressed in grams or in terms of the number (N) of atoms present These problems do not differ in any essential respect from those encountered in dealing with other elements; the radioactive properties of the element enter into the problem mainly as a means by which different amounts of the material can be compared

In problems of the second class the results may likewise be expressed as functions of the total weight, or of the total number of atoms, of the element present, but when this is done certain fundamental relations are obscured. Only a relatively small fraction (λN) of the atoms present take part in the phenomenon studied, and the thing that is of fundamental interest is the effect produced per atom actively concerned It is in this effect per active atom that information regarding the atomic forces, structure, and instability, and the way these vary from element to element, are to be sought. In such problems one is concerned with the number of atoms that have transformed in a certain time, he is but incidentally interested in the presence of atoms that have remained untransformed. He wishes to know

[1] Contribution from the Bureau of Standards. Received August 1, 1921.

the energy emitted per transformed atom, the number of alpha particles emitted per transformed atom, etc. If his observations extend over a time t, he wishes to know the number of atoms transformed during that time; *i e.*, λNt where λ is the transformation constant, and N is the total number of atoms present. He is primarily interested in λN, rather than N.

When only a single element is being considered it is a matter of indifference whether the result is expressed in terms of grams, or of N, or of λN. But when similar measurements have been made for two different elements, and it is desired to compare the results obtained these must each be expressed in terms of the quantity, λN, involved, if fundamental relations are to be obtained. For example, if it is desired to compare the heating effect produced by the transformation of radium with that produced by the transformation of radium emanation, then these effects are expressed in gram calories per hour per gram of radium, and per that amount of radium emanation that can exist in equilibrium with one gram of radium; λN is the same for each of these quantities. This is quite satisfactory when only related elements in an unbranched portion of a family are being considered, but if a lateral branch arises between the first and the second element, then a more complicated description of the reference amount of the second element is required. For example, uranium-II branches into uranium-Y and ionium, some 4 per cent going into the former, consequently the heating effect of one gram of uranium-II is not strictly comparable with the heating effect of the amount of ionium that can exist in equilibrium with one gram of uranium-II, but with 1/0 96 of the latter amount.

When the effects of elements belonging to unrelated families are to be compared, they will likewise be referred to quantities having the same value for λN; *i e.*, to quantities so chosen that the same number of atoms take part in the production of the effect. For one element the result may be expressed in terms of the effect per gram, but the corresponding quantity of the other element cannot be very directly expressed with our existing terminology.

This difficulty would be removed if there were a name to denote the amount of a radio-element corresponding to a fixed value of λN. For example, if λN for one gram of radium is equal to k, and that amount of any element for which $\lambda N = k$ is called an r, then an r of any element will be radioactively comparable in amount to an r of any other element, whether related or not. A gram of radium will contain one r of radium, a curie will contain one r of radium emanation,

the amount of radium-A that can exist in equilibrium with one gram of radium will contain one r of radium-A, the amount of ionium that can exist in equilibrium with one gram of radium will contain one r of ionium, the amount of uranium-II that can exist in equilibrium with one gram of radium will contain (1/0.96) r of uranium-II, etc.

As thus defined, an r of any material is *that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium.*

The value in grams or in atoms of an r of any element depends upon the ratio of the transformation constant and of the atomic weight of the element to those of radium; denoting the transformation constant of radium by λ_0, the number of atoms in one gram of radium by N_0 and the atomic weight of radium by A_0 the number of atoms (N) in one r of any other element is determined by the equation

$$N = \frac{\lambda_0}{\lambda} \cdot N_0$$

and the weight in grams of one r of the element is

$$NA = \frac{\lambda_0}{\lambda} \frac{A}{A_0}$$

since N_0A_0 is by definition equal to one gram

To the precision with which the transformation constants are known, an r of radium emanation weighs $6\,55 \times 10^{-6}$ gram, of radium-A, 3.54×10^{-9} gram; of uranium-II, 1.51×10^{2} gram, of actinium, 1.29×10^{-2} gram; of mesothorium-1, 4.29×10^{-3} gram.

The quantity that we have denoted by the letter r plays in radioactivity a part that is analogous to that played by the gram-molecule in physical chemistry; the adoption of some name for it will appreciably facilitate the recording, discussion, and presentation of radioactive observations and phenomena.

One illustration of the increased facility that will be secured by the adoption of a name for this quantity is afforded by the frequent use of expressions of the form "radium-C corresponding to one gram of radium" (Rutherford), "von der mit 1 g. Ra in Gleichgewicht stehenden Ra-C Menge" (Hess); these would be replaced by the much simpler "one r of radium-C," where the letter r stands for the name adopted.

Another illustration may be taken from the surgical application of the active deposit of radium. When it is desired to state the amount of, say, radium-C present, a circumlocution like those in the preceding paragraph is required. This long and awkward expression is fre-

quently abbreviated to the form "x mg. of radium-C," or to "x millicuries of radium-C" Such abbreviations may lead to serious misunderstanding and confusion, and can readily be replaced by the exact and unambiguous expression "x mr of radium-C," so soon as a name has been given to the quantity r.

The customary expression for the rate of accumulation of a radioelement is

$$\frac{dN_2}{dt} = \lambda_1 N_1 - \lambda_2 N_2$$

where N_1 and N_2 denote, respectively, the total number of atoms of two successive elements. The rate of accumulation of element 2 is made to depend upon both λ_1 and λ_2, although it is evident that the instantaneous growth of element 2 can ultimately depend upon only its own constant and its departure from equilibrium. This is brought out plainly when quantities of the elements are measured in terms of r Let there be R_1 r's of element 1 and R_2 r's of element 2; as before, let k denote the number of transformed atoms produced in unit time by one gram of radium, *i.e.*, by one r. Then kR_2 will be the number of atoms of element 2 that transforms in a unit of time, hence $kR_2 = \lambda_2 N_2$, where N_2 is the number of atoms of element 2. Whence

$$\frac{dN_2}{dt} = \frac{k}{\lambda_2} \cdot \frac{dR_2}{dt}$$

But

$$\frac{dN_2}{dt} = k(R_1 - R_2)$$

Hence

$$\frac{dR_2}{dt} = \lambda_2 (R_1 - R_2)$$

If $R_1 = R_2$ the two elements are in equilibrium. The differential equation shows at once that the instantaneous growth of element 2 is equal to the product of λ_2 by the departure from equilibrium.

The coefficients in the equation applying to the decay of a group of elements initially in equilibrium (Case 2 of Rutherford) are unsymmetrical when the equations are written in the usual notation, the total number of atoms present being the unit. For example, the coefficients for the third element (Rutherford's R) are

$$a = \frac{\lambda_2}{(\lambda_2 - \lambda_1)(\lambda_3 - \lambda_1)}; \quad b = \frac{\lambda_1}{(\lambda_1 - \lambda_2)(\lambda_3 - \lambda_2)}; \quad c = \frac{\lambda_1 \lambda_2}{\lambda_3 (\lambda_1 - \lambda_3)(\lambda_2 - \lambda_3)}.$$

When the unit is the r these coefficients become

$$a = \frac{\lambda_2\lambda_3}{(\lambda_2-\lambda_1)(\lambda_3-\lambda_1)}, \quad b = \frac{\lambda_3\lambda_1}{(\lambda_1-\lambda_2)(\lambda_3-\lambda_2)}; \quad c = \frac{\lambda_1\lambda_2}{(\lambda_1-\lambda_3)(\lambda_2-\lambda_3)}$$

In these the symmetry is perfect.

A name for the quantity r would be most useful when curves similar to those given by Rutherford as figures 102, 103, 110 (*Radioactive substances and their radiations*) have to be plotted. The ordinates of these curves are proportional to the number of r's of the several elements, and to the sum of these r's. If the alpha particles from each element are equally effective in producing the effect measured, the total effect is proportional to the sum of the r's and on this assumption the ordinates are proportional to the "activities." In lieu of a name for the quantity r the ordinates are labeled "activities," and the assumption is explained in the text. Were there a name for the quantity r the ordinates could be so marked and no assumption would be required.

It has been shown how the weight of an r of any element can be computed. Consequently there is no serious difficulty in determining the number of r's contained in a given amount specified in grams; or conversely. In the portion of the radium family comprised between ionium and radium-C, both inclusive, the elements are now actually measured in terms of r, which in this region may be regarded as merely an abbreviation of the oft recurrent phrase "amount that is in equilibrium with one gram of radium." Beyond these branch points a factor depending upon the branching ratio must be introduced. Several methods are available for determining the value in r's of a radioactively defined amount of an element of another family. If a chemically pure salt of known composition either of this element or of another genetically related to it and not separated from it by a branch point has been prepared, we can determine at once the value of λN for a gram of that element. The ratio of this to k will be the number of r's in a gram of that element, and likewise in such amounts of its derivatives as can exist in equilibrium with a gram of it. Or the number of alpha particles emitted per second by the material considered or by an equilibrium amount of a related element might be determined. This number divided by 3.72×10^{10} (the value for one gram of radium, *i.e.*, the quantity we have denoted by k) will be the number of r's in the quantity considered, unless more than one alpha particle is emitted during a single transformation of an atom; this can be determined by suitable observations.

For many reasons it is desirable to have a name for the quantity which we have designated by the letter *r*. Thus arises the question whether the term "curie," which by international agreement is an *r* of radium emanation, shall be redefined so as to cover the entire field embraced by our definition of the quantity *r*, or whether a new name shall be added to the nomenclature of the science. In the latter case the name *rutherford* seems most appropriate.

In order to obtain an expression of opinion regarding the advisability of adopting a new name for the quantity we have denoted by the letter *r*, the Bureau of Standards submitted the preceding portion of this paper, in essentially its present form, to a number of chemists and physicists. While agreeing that it is desirable to have a name for the quantity *r*, the replies were divided regarding the advisability of adding a new name to the nomenclature. The majority of the replies favored the extension of the "curie" to cover the entire field, so as to avoid the existence of two names to denote the same amount of radium emanation.

Such an extension involves a redefinition of the curie. The extended term cannot be defined as the amount of an element that is in equilibrium with a known amount of any other element, though for the elements of the uranium family from ionium to radium-C it will actually denote the amount of these elements that can exist in equilibrium with one gram of radium. Neither should it be thought of as that amount of an element that under certain conditions will give a fixed, specified ionization current. Its definition must be equivalent to the one we have given for *r*; namely, as thus extended, a curie of any material will be that amount of the material that will produce transformed atoms at the same rate as transformed atoms are produced by one gram of radium.

MINERALOGY.—*Lazulite of Graves Mountain, Georgia, with notes on other occurrences in the United States.*[1] THOMAS L. WATSON, University of Virginia.

Graves Mountain, Georgia, is located in Lincoln County about 10 miles west from Washington, Wilkes County, the nearest railroad point. The locality has long been known to mineralogists for the occurrence of rutile and lazulite in association with a group of more common minerals. These are, named without regard to order of abundance, lazulite, rutile, cyanite, pyrophyllite, hydrous antho-

[1] Received July 18, 1921.

phyllite, hematite, quartz, and muscovite. In addition to these, Shepard[2] reported barite, minute perfectly formed transparent crystals of sulfur, crystals of pyrite, and traces of gold. The locality is probably best known for the occurrence of rutile, crystals of which have been figured and described by European crystallographers.

The ridge locally known as Graves Mountain has a length of 2 miles along an approximate northeast-southwest direction, is less than half a mile wide, and rises several hundred feet above the surface of the surrounding Piedmont Plain. The slopes of the ridge are very unequal, and are greatly roughened from weathering.

Graves Mountain is composed of Cambrian quartzite of which there are two facies:[3] (1) a foliated quartzite schist which forms the basal portion of the ridge and extends some distance up the slope on the northwest side, and (2) a fine-grained massive quartzite (itacolumite), which forms the crest and upper slopes. Both are composed dominantly of quartz with the difference in chemical composition shown in the following partial analyses:

	Quartzite schist	Massive quartzite (itacolumite)
SiO_2	70 18	69 74
Al_2O_3	14 14	24 86
Fe_2O_3	3 17	0 53

Igneous rocks are not known to occur in the ridge proper, but are common in the surrounding area.

Lazulite, a rare basic phosphate of aluminum, magnesium, and ferrous iron, corresponds to the formula (Fe, Mg) $(AlOH)_2(PO_4)_2$ in which the ratio of Fe:Mg(Ca) varies[4] from 1:12 to 2:3. It and the associated minerals occur in the itacolumite of the crest and higher slopes of Graves Mountain. The lazulite is irregularly distributed through the itacolumite in rude nests or bunches of single crystals and crystal aggregates. Quartz veins of a few inches thickness cut the quartzite on top of the ridge and sometimes carry rutile, pyrophyllite, and iron oxide, but lazulite has not been observed in them The lazulite is imbedded in the itacolumite usually as crystals which range in size up to an inch in length, but as a rule the individual crystals are much smaller. It also occurs massive without distinct crystal boundaries. The crystals are usually acute pyramidal in

[2] C. U. Shepard. Amer. Journ. Sci. 27: 36–39. 1859.

[3] For a detailed description, including petrography, of the two facies of the quartzite, see Thomas L Watson and J Wilbur Watson, *A contribution to the geology and mineralogy of Graves Mountain, Georgia.* Univ. of Virginia Publications, Bull. Philos. Soc., Sci Sec, 1: 220–221 (No 7). 1912.

[4] E. S. Dana. *A system of mineralogy*, pp 798–799

habit and frequently twinned. Shepard[8] described and figured five crystals of lazulite from the Georgia locality, and stated that a twin (his fig. 5) "is by far the most abundant form equalling in frequency all the others combined."

The mineral is opaque, of azure blue color when fresh, has uneven fracture, indistinct cleavage, and vitreous luster. Blow-pipe tests gave the usual reactions characteristic of the mineral. The lazulite is frequently intergrown with greenish to colorless columnar cyanite which is partly altered to muscovite (damourite), and is less often intergrown with coarse white quartz. Small grains of red rutile and of colorless quartz, especially the former, form frequent inclusions in the blue lazulite. The cyanite weathers yellow-brown in color and, like the lazulite, also contains inclusions of red rutile and colorless quartz. Similar red grains of rutile are also frequent in the quartzite. Weathered surfaces of the lazulite-bearing portions of the itacolumite are generally rough from the more resistant coarse lazulite and cyanite standing in relief. Scales of colorless mica are more or less conspicuous in weathered specimens of the rock.

When weathered, the lazulite is of lighter or paler blue color, sometimes almost entirely white or colorless, but is frequently spotted or mottled white and blue. Microscopically, thin sections show alteration of some of the lazulite along the periphery and fractures, into minute scales and fibers of a light gray nearly white substance, sometimes stained with iron oxide, having high refraction and double refraction, which probably can be referred to hydrargillite.

Under the microscope thin sections of the lazulite show inclusions of rutile and quartz, and occasionally cyanite and muscovite, all of which are common associates in hand specimens of the lazulite.

The lazulite is light blue in thin section and distinctly pleochroic, with $Z = Y > X$. It is optically negative (–), with 2V large.

The dispersion is slight, $\rho < V$. The values for the indices of refraction and the birefringence determined by Dr. E. S. Larsen on specimens of the lazulite yielding the analysis given below are as follows:

$$\alpha = 1.604, \text{ nearly colorless}$$
$$\beta = 1.633, \text{ deep blue}$$
$$\gamma = 1.642, \text{ deep blue}$$
$$\gamma - \alpha = 0.038$$

A chemical analysis of the lazulite yielding the above optical data is given in table 1.

[8] C. U. SHEPARD. *Op. cit.*

The formula derived from the column of ratios in table 1 is that given in the standard texts for the mineral, except that CaO is usually not expressed:

$$(Fe, Mg\ (Ca))\ O.Al_2O_3.P_2O_5.H_2O$$

with FeO:Mg(Ca)O = 1:5, FeO:CaO = 1:1, and MgO:CaO = 4:1

When compared with analyses of lazulite from other localities the Georgia mineral shows a high percentage of CaO (3.30 per cent), the largest reported in any analysis of the mineral of which the writer has found record. The analysis of lazulite from North Carolina quoted by Dana[6] shows no CaO. With two exceptions, Georgia and North Carolina, analyses of lazulite thus far published represent

TABLE 1 ANALYSIS OF LAZULITE

	I	II	III	
P_2O_5	38.25	40.61	286	1
Al_2O_3	33.92	36.02	353	1.2
FeO	3.99	4.24	59	
MgO	9.08	9.64	241	1.3
CaO	3.12	3.30	59	
H_2O	5.83	6.19	343	1.2
SiO_2	6.05			
	100.24	100.00		
Sp. G.	2.958			

I. Lazulite collected by Thomas L. Watson from Graves Mountain, Lincoln County, Georgia J. Wilbur Watson, analyst

II Analysis I with the SiO_2, which represents admixed quartz, deducted, calculated to 100 per cent.

III Ratios from II

foreign localities, in which CaO is indicated as being either absent or present in quantity of less than 1 per cent. The only exception found by the writer is an analysis of lazulite quoted by Dana[7] from near the mouth of Churchill River, Keewatin, Canada, in which CaO is given as 2.83 per cent. Based on CaO content, published analyses of lazulite, most of which are old, would group the mineral under (*a*) calcium lazulite, apparently the less frequently occurring variety, to which the mineral from Graves Mountain, Georgia, and Keewatin, Canada, belongs; and (*b*) essentially calcium-free lazulite which includes the more common variety of the mineral represented by analyses from many European localities.

OTHER OCCURRENCES OF LAZULITE IN THE UNITED STATES.

Lazulite occurs both as crystals and as massive granular to compact material in quartz veins and in metamorphic rocks, especially quartz-

[6] E. S. DANA. *Op. cit.*, p. 799.

[7] E. S. DANA. *Op. cit.*, p. 799.

ites of the variety itacolumite. When fresh its azure blue color, vitreous luster, indistinct cleavage, and hardness (5–6) are the more important megascopic properties. It is subtranslucent to opaque, and has a specific gravity of 3 ±.

The known occurrences of lazulite in the United States are limited to North Carolina, South Carolina, and Georgia in the southeast Atlantic States,[8] and to California on the Pacific coast.

The localities are Graves Mountain, Lincoln County, Georgia; Chesterfield district, South Carolina; Clubb and Crowder Mountains, Gaston County, and Sauratown, Stokes County, North Carolina. The largest number of occurrences is in California, where the mineral has been reported from the following localities:[9] Breyfogle Canyon in Death Valley, Inyo County; San Gabriel Mountain, Los Angeles County; near Mono Lake and in Green Creek Canyon near Bodie, Mono County; and Oceanside, San Diego County. Foreign occurrences of lazulite have been reported from localities in Austria, Switzerland, Sweden, Brazil, and Canada.[10]

Probably the first occurrence of lazulite noted in the United States was by H. S. Hunter in 1822, near Crowder Mountain in the southern part of Lincoln (now Gaston) County, North Carolina. The mineral was found later in greater abundance near the southern end of Clubb Mountain, about 30 miles northeast of Crowder Mountain. Its occurrence in the North Carolina and Georgia localities is in Cambrian quartzite, as crystals and crystal aggregates irregularly distributed through the rock, usually in nests or bunches. With the exception of corundum, which is unknown in the Georgia locality, the mineral associates of lazulite in the two states are the same. They include rutile, cyanite, pyrophyllite, quartz, and damourite. The mineral association in the Chesterfield district, South Carolina, is, according to Genth,[11] pyrophyllite and cyanite.

Unlike the occurrences of lazulite in the Carolinas and Georgi a

[8] C. L. HUNTER. Amer. Journ. Sci. 15: 376–377. 1853. J L SMITH and G J. BRUSH. Amer. Journ Sci. 16: 370. 1853. C. U. SHEPARD. Am Journ. Sci. 27: 36–39. 1859. F. A. GENTH. Amer Phil. Soc. 13: 367, 382, 383, 404–405. 1873 E. S. DANA. *A system of mineralogy* (1900), p 799 G. F KUNZ. N. C Geol. Survey Bull. 12: 57. 1907. T L WATSON and J W. WATSON Univ. of Virginia. Publ Bull. Phil. Soc, Sci Ser., 211–214 (No. 7). 1912

[9] A. F ROGERS Sch. of Mines Quart. 33 375 1912 D. B. STERRETT U. S Geol. Survey, Min Res for 1911. Pt II, p 1060 A. S. EAKLE. Calif. State Mining Bureau, Bull 67: 162 1914

[10] For more details of foreign localities see E. S DANA, *loc. cit*

[11] F A GENTH Amer. Journ. Sci. 18: 410. 1854.

the mineral is found in quartz veins in some of the California localities, but its occurrence at Mono Lake in quartzite is similar to that in the southeast Atlantic states. Fewer minerals are associated with lazulite in the California localities, but those noted are also found in the southeast Atlantic states. In Green Lake Canyon,[12] near Bodie, lazulite is developed in deep blue anhedra associated with quartz and muscovite in a quartz vein; and in Breyfogle Canyon,[13] Death Valley, it is distributed as crystals and crystal aggregates of pale to fairly deep azure blue in patches through a white quartz vein cutting schist. At Mono Lake [14] it is associated with rutile in bands in a white quartzite.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue

INORGANIC CHEMISTRY.—*The crystal structure of some carbonates of the calcite group.* RALPH W. G. WYCKOFF. Amer. Journ. Sci. **50**: 317–360. 1920

By the same general method that has been employed in studying caesium dichloriodide and sodium nitrate, a unique solution has been obtained for the crystal structures of calcite and rhodochrosite. Of the assumptions commonly made in crystal-structure study, the only one required in this determination was that the atoms reflect X-rays in an amount roughly proportional to their atomic numbers. The structure of siderite was shown to be so nearly the same as that of rhodochrosite as to be indistinguishable by the means at hand. Magnesite was also found to give the same sort of pattern and hence to have the same general arrangement of atoms as the other members of the group.

The positions of the oxygen atoms, as determined by the present method and by the spectrometer results, are compared. In this particular case, the "normal" decline of intensities is in surprising agreement with the reflections. Evidence is obtained from these crystal structures to show the existence of groups of atoms, as carbonate groups, in the crystal. It is also pointed out that unless every atom in the crystal is electrostatically charged, the outside electrons of the atoms making up these crystals cannot be arranged at the corners of cubes.

Some connections are pointed out between the development of faces on calcite and its crystal structure, and a way is indicated of deciding the most probable indices of a plane when they are in doubt. The bearing of these structures upon the question of what constitutes a series of isomorphous substances is mentioned.

A criterion is suggested for determining, in the case of an hexagonal crystal, whether the fundamental unit is a rhombohedron or an hexagonal prism.

[12] A. F. ROGERS. *Op cit.*, p 375.

[13] D. B. STERRETT. *Op. cit.*, p. 1060.

[14] A. S. EAKLE. *Op. cit*, p. 162.

The use of gnomonic projection in studying Laue photographs is mentioned and a ruler is described, the use of which reduces the time and labor of making such projections. The effect of the voltage impressed on the X-ray tube upon the character of the Laue photograph is considered and the best conditions for operating a tungsten tube for this work are stated. R. W. G. W.

PETROLOGY.—*The rhyolites of Lipari.* HENRY S. WASHINGTON. Amer. Journ. Sci. 50: 446–462. 1920.

Typical obsidians, pumice, lithoidal rhyolite, and a hyalo-dacite of Lipari are described, with six new analyses. As these rhyolites are regarded as typical and have never before been completely analyzed, this work is of use in characterizing the type. The refractive indices of the obsidians and pumice are discussed. There is also given an analysis of an obsidian of the island of Milos, of which the refractive index was also determined. The data correspond well. This is compared with analyses of obsidian of Nisyros by Martelli. The observation is made that ferrous oxide dominates ferric oxide in the glassy forms of the same magma, while the converse is true of the crystalline forms in the Lipari rhyolites. The same holds good for the rhyolites of Sardinia and the pantellerites and basalts of Pantelleria, described some years ago by the writer. The possible relation of this to the magmatic gases in lavas is briefly discussed. H. S. W.

GEOLOGY.—*The potash deposits of Alsace.* H. S. GALE. U. S. Geol. Survey Bull. 715-B. Pp. 39, pls 2, figs. 2. 1920.

The discovery of potash in Alsace in 1904 broke the monopoly of the potash industry which since 1860 had rested with the producers in north-central Germany. The return of Alsace to France now divides the monopoly between two nations. The new field, although of less extent, is in some ways better than the older field; the beds are very regular, and the salts average remarkably high in potash. The deposits, which were discovered accidentally in boring, underlie an area of 65 square miles beneath the valley of the Rhine in southern Alsace. They consist of two regular beds of sylvinite, a simple mixture of potassium and sodium chlorides, included in dolomitic grayish shale of middle Oligocene age. The writer believes that the beds were deposited by evaporation in an inland salt-lake in the Rhine graben, which probably had no connection with the sea. Förste estimated the reserve of the field as 300,000,000 tons of pure potash, but by no means all of this can be recovered in mining. The crude salt mined in 1913 is reported as 350,341 tons, probably averaging 18 per cent in pure potash. J. D. SEARS.

GEOLOGY.—*A deposit of manganese ore in Wyoming.* EDWARD L. JONES, JR. U. S. Geol. Survey Bull. 715-C. Pp. 3 1920.

One of the few manganese deposits known in Wyoming is on the western flank of the Laramie Mountains, near the head of Sheep Creek. The core of the Laramie Mountains is a coarse-grained red granite of pre-Cambrian age, but flanking it on the west side is a series of sedimentary rocks ranging in age from Carboniferous to Cretaceous. The manganese deposit is interbedded in limestone and sandstone of the Casper formation, of Carboniferous age. The ore consists of the manganese oxides manganite and pyrolusite, in mammillary crusts and nodular aggregates, and is unusual for its number of crystals It is contained in two beds of chert a few feet apart, from which it is thought to have been derived by weathering and leaching. J. D. SEARS.

GEOLOGY.—*Some deposits of manganese ore in Colorado.* EDWARD L. JONES, JR. U. S. Geol. Survey Bull. 715-D. Pp. 12. 1920.

Many deposits of manganese ore in Colorado have been described by J. B. Umpleby in 1917 and the Colorado Geological Survey in 1918. A number of other localities were examined by the writer in 1917; these are located in Gunnison, Hinsdale, Ouray, Dolores, Custer, and LaPlata Counties.

Deposits of manganese ore in Colorado occur in sedimentary and igneous rocks ranging in age from pre-Cambrian to Tertiary. They are found in veins and brecciated zones; as replacement deposits; and as probably original bedded deposits. The veins and brecciated zones constitute by far the most numerous type of manganese deposits in Colorado, but economically they have proved of little importance. Replacement deposits of manganese ores occur principally in the oxidized parts of lead-silver deposits in the Leadville district, and of deposits containing zinc and iron sulfides in the Red Cliff district. A deposit of manganese ore which probably represents the oxidized and enriched part of an original sedimentary bed occurs in sandstone and shale in western San Miguel County. The manganese ores are composed dominantly of the oxides pyrolusite, manganite, psilomelane, and wad, generally mixed with iron oxides. J. D. SEARS

GEOLOGY.—*Deposits of iron ore near Stanford, Montana.* L. G. WESTGATE. U. S. Geol. Survey Bull. 715-F. Pp. 8, figs. 4. 1920.

The iron ores known as the Running Wolf hematite deposits lie just within the northern border of the Little Belt Mountains, in Cascade and Fergus Counties, Montana. A great series of sedimentary rocks, ranging in age from Algonkian to Cretaceous, rests unconformably upon Archean granite and gneiss. The deposits occur in tabular bodies in the Madison limestone (Carboniferous), at the contact with intrusive porphyry. The ore is a compact gray or reddish-gray hematite, which contains in places enough magnetite to make it react to the magnet; it is not to any large degree limonitic at the surface.

Development work has not gone far enough to make possible any estimate of the quantity of ore that can be mined, although several suggestive calculations are included in the paper. At the surface the ore body is of varying width, reaching a maximum of 50 feet. As it is a contact deposit in limestone, it will vary in dimensions from place to place according to the character and course of the solutions at work. The depth to which the ore extends below the surface is unknown. J. D. SEARS.

GEOLOGY.—*Phosphate rock near Maxville, Granite County, Montana.* J. T. PARDEE. U. S. Geol. Survey Bull. 715-J. Pp. 5, pl. 1, fig. 1. 1921.

The phosphate bed and its inclosing rocks are bent into several parallel, tightly squeezed folds that trend northward. The westernmost fold, a large syncline, is partly overridden by a huge mass of rock brought by thrust faulting from the west, and the strata that form the western limb of the syncline appear as if overturned by a force acting from the west. East of the syncline and beyond the area of the overthrust mass all the anticlines lean to the west as if they had been pushed over by a force acting from the east. Presumably the thrust acting from the west was the later. On the south the folds are lost in areas of faulted and intrusive rocks, and on the north, owing to a persistent pitch in that direction, they disappear beneath a cover of later rocks. As a result of the structure and erosion combined, the out-

crop or surface trace of the phosphate bed forms a sinuous line that sweeps north and south, alternately bending sharply around the anticlines and synclines.

One hundred million tons of phosphate rock are estimated in reserve, of which a considerable part lies above the natural drainage channels in situations especially favorable for mining. J. T. P.

VOLCANOLOGY.—*The Katmai region, Alaska, and the great eruption of 1912.* CLARENCE N. FENNER. Journ. Geol. 28: 569–606. 1920.

A preliminary account is presented of observations made by the writer as geologist of the expedition sent in 1919 by the National Geographic Society, in cooperation with the Geophysical Laboratory of the Carnegie Institution of Washington, to the Katmai region, Alaska.

The volcanoes of this region, which form a continuation of the Aleutian loop or festoon, are situated in an area of sedimentary rocks remarkable for the absence of folding or obvious faulting. The more recent lavas are basic andesites, contrasting greatly in composition with the highly siliceous rhyolite of the last eruption.

It is believed that in the fumarolic area of the Valley of Ten Thousand Smokes the injection of a sill or closely similar body of magma into the underlying strata at the beginning of the eruption caused shattering of the rocks above it, and these openings permitted the ascent of magma. The extrusion and inflation of this magma gave rise to a great ash-flow or sand-flow, analogous in many respects to the *nuées ardentes* of Pelée and La Soufrière, and also led to the formation of the parasitic cone of Novarupta. The fumaroles are thought to be due to the continued evolution of volatile constituents from this body of magma. The development of the new vent of Novarupta is ascribed to the enlargement of a channel along one of the fissures. The later extrusion of the stiff lava forming the dome of Novarupta is found to have been similar in many respects to that of the "spine" of Pelée.

A study was made to determine the manner in which the top of Mount Katmai disappeared and the great crater-pit was formed. It seems quite certain that the material was not blown out directly, but must be accounted for otherwise. Crater subsidence may have been a factor, but it is believed that collapse of the crater-walls and incorporation of the material in the new magma were chief features. It is recognized that the latter process demands a large quantity of heat for its accomplishment, and the magma evidently was not at very high temperature prior to extrusion; therefore accessions of heat seem to be demanded. A considerable problem is thus presented, but it does not seem at all insuperable, and it is believed that the evidences of solution are so strong that they cannot be disregarded.

One of the important features of the eruption brings up for consideration a phenomenon to whose significance little attention seems to have been paid hitherto. It is that of a gas-charged magma gradually developing the explosive condition after some interval has elapsed subsequent to its ascent from the depths. The Katmai magma seems to have followed this course, and the phenomenon is apparently not uncommon. This is believed to have great significance and to imply changes of physical environment during its ascent, effected with such rapidity that internal readjustments were not able to keep pace with them. C. N. F.

ENTOMOLOGY.—*The Dipterous genus* Dolichopus *Latreille in North America.* M. C. Van Duzee, F. R. Cole and J. M. Aldrich. Proc. U. S. Nat. Mus., Bull. 116. Pp. 304, pls. 16. 1921.

This paper is a revision of the North American species of the genus *Dolichopus*. It is divided into three parts. The introduction by J. M. Aldrich gives a historical account of the genus and notes on the habits of certain species. The second part, entitled "Classification," by M. G. Van Duzee, occupies the largest portion of the work. In it 219 North American species, many of which are new, are described, the location of the types is stated and there is an account of material before the author. This section is introduced with a synoptic table of the species. The males are treated first and are divided into nine groups. The females are also tabulated, but do not fall into the same groupings as do the males. This is due to the unusual and peculiar secondary sexual characters of the males. The third part is by F. R. Cole and consists of considerably more than 217 figures illustrating various characters of the species treated. Each species is assigned a number and when two or more figures are given for the same species they are given subletters of the species numbered.

This division of the paper in three parts makes it appear that the new species are to be accredited to Mr. M. C. Van Duzee and no statement to the contrary is definitely made, but in the introduction it is implied that new forms should be accredited to the three authors. The present writer understands that such is the intention of the authors of this important and comprehensive work. S. A. Rohwer.

ETHNOLOGY.—*The Owl sacred pack of the Fox Indians.* Truman Michelson. Bur. Amer. Ethnology, Bull. 72. Pp. 83, pls. 4.

The greater part of this bulletin consists of a text in the language of the Fox Indians and a translation of the same setting forth the ritual connected with it, its history, and the benefits supposed to follow upon the performance of the ceremonies. Some linguistic notes on the text are appended and a list of stems fills the 12 concluding pages. It contains contributions to the study of Indian linguistics, sociology, and religion. John R. Swanton

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

851st meeting

The 851st meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club, May 7, 1921. It was called to order by President Faris with 30 persons present.

The first paper, on *The self contained base range finder and its errors*, was presented by Mr. I. C. Gardner (by invitation) and was illustrated.

The self-contained base range finder is probably the most interesting and highly developed optical instrument employed in warfare. The range is determined by triangulation with the base of the triangle actually contained within the instrument. It follows that the angle of parallax which is measured is extremely small and must be measured with great accuracy. For example, with a one-meter instrument at a range of 5000 meters the angle is approximately 40 seconds. The error of measurement for this angle must be less

than one second if an accuracy of 2 per cent in the determination of range is to be secured. To build an instrument which shall successfully attain this accuracy under service conditions and in the hands of men not thoroughly grounded in laboratory practice calls for the greatest refinement of optical and mechanical design.

The errors to which a range finder is subject are of two kinds. The adjustment error is a systematic error which is constant, when measured in angular units, for all settings of the instrument and may be considered as corresponding to a bodily shifting of the entire scale of the instrument with respect to the index. An adjustment is provided for correcting this error in the field.

The dispersion error is an accidental error arising from the inability of the observer to correctly determine precise coincidence in the field of the instrument. It may be either positive or negative and its distribution for a large number of observations may be expected to be in accordance with the ordinary frequency curve for errors. This error can be studied satisfactorily only by a laborious statistical method. A test has recently been completed at Fort Sill by the Ordnance Department with the cooperation of the Field Artillery and the Bureau of Standards which was represented by Mr. W. O. LYTLE. Approximately 21,000 separate readings of range were taken by a group of average observers with 17 different instruments on a selected series of targets. The most probable value of the dispersion error was found to be of the order of 0.9 second. Much greater differences were found in the dispersion errors of the different observers than in those of the different instruments. This indicates that at present the selection and training of observers offers a much better prospect for an immediate and spectacular increase in the accuracy of range finding than does the careful selection of an instrument from those types now available. For the poorer observers the dispersion error was approximately twice that of the better. In other words the poorer observer requires a two-meter base range finder in order to obtain an accuracy equal to that of the better observer with the one-meter instrument.

The paper was discussed by Messrs. HAWKESWORTH, WRIGHT, SOSMAN, HUMPHREYS, and FARIS.

The second paper, on *The spectral distribution of energy required to evoke the gray sensation,* was presented by Mr. IRWIN G. PRIEST and was illustrated.

The chief significance of this paper lies in the development and testing of an experimental method for determining an objective physical standard of "white light." The standard to be determined is the Planckian ("black body") distribution of energy required to evoke the hueless sensation of brilliance, commonly called "white" or "gray," under certain standard conditions stated in detail in the paper.

The method of producing and adjusting the spectral distribution of the stimulus is this: Light from a lamp of known spectral distribution is modified by rotary dispersion in a system of quartz plates and nicol prisms in such a way that by rotating one of the nicols the light emerging from it can be made to assume the spectral distribution of a Planckian radiator at any desired temperature between 4000° and 7000° K. Such a system is, in effect, a selective light filter of adjustable spectral transmission.

Two methods of observation were described: (1) The method of adjustment by trial, in which the observer himself adjusts the stimulus until he calls the sensation "white." (2) The method of answers, in which the operator conducting the experiment adjusts the stimulus to correspond to certain fixed temperatures of the hypothetical Planckian radiator; and records the

observer's reactions as "blue," "white," or "yellow," as the case may be. The second method proved to be the more satisfactory.

Experimental results were given from four observers. The average results of these observers indicate that "white light" may be represented: (1) theoretically, by the light from a Planckian radiator at a temperature of about 5200° absolute; (2) practically, to a fair approximation, by average noon sunlight at Washington. It is, however, emphasized that the final establishment of such a standard should be based on a more extensive statistical investigation.

The paper was discussed by Messrs. Gardner, Hawkesworth, Faris, Burgess, Tuckerman, Sosman, and others.

The complete paper is being published as a Bureau of Standards Scientific Paper.

852d meeting

The 852d meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club, May 21, 1921. It was called to order by President Faris with 36 persons present.

The first paper, on *Relation of coastal currents and winds on the Pacific Coast* was presented by Mr. H. A. Marmer and was illustrated.

This paper presented the results of an investigation of the speeds and directions of the current along the Pacific Coast of the United States brought about by local winds. The investigation was undertaken primarily for the purpose of aiding the mariner and was based on observations made under the direction of the Coast and Geodetic Survey by members of the crews of the five light vessels stationed along the coast from San Francisco Bay to the Strait of Juan de Fuca. The apparatus used for measuring the speed and direction of the current was necessarily the simplest, and consisted of a 15 foot current pole, a log line graduated to knots and tenths for a run of one minute, a stop watch, and a pelorus. The wind velocity was estimated in accordance with the Beaufort Scale.

Since the current as observed is the resultant of a number of different currents due to various causes, such as tides, winds, river discharge and differences in density, the observations are tabulated with reference to various arguments. Thus by tabulating with reference to time of tide at a nearby port for periods of 29 days, the tidal current is derived. This current on the Pacific Coast, offshore, is of the rotary type, the direction of rotation being clockwise, and shows considerable diurnal inequality. The wind current is derived by tabulating the observations with reference to winds of particular velocity and direction; then by summing for each such wind a large number of observations, the tidal-current may be considered as very nearly eliminated.

In the present investigation the observations were tabulated with reference to winds from a given direction divided in groups covering a range of wind velocity of 10 miles The results derived show that on the Pacific Coast at a distance of from 4 to 10 miles from the land, winds from 10 to 70 miles per hour will give rise to currents from 1/4 of a knot to over a knot; and this current will set, not in a direction of the wind, but in a direction of about 20° to the right of the wind. This has an important bearing on navigation, since winds blowing parallel to the coast or even away from the coast may give rise to currents tending to set a vessel on shore.

In the results presented for each of the light vessels the effect of fresh-water run-off at the light vessels stationed off San Francisco, Columbia River and

Swiftsure Bank was sufficiently large in some cases to change the direction of the current brought about by winds of moderate velocity from the characteristic deviation of 20 degrees to the right of the wind direction. But with increasing wind velocity the direction of the current approximated toward the direction of 20 degrees to the right of the wind.

This paper, which was illustrated by lantern slides, will form part of a Special Publication of the Coast and Geodetic Survey, dealing with currents on the Pacific Coast, to be published in the near future. It was discussed by Messrs. LITTLEHALES, FARIS, WHITE, WILLIAM BOWIE, and HUMPHREYS.

The second paper, on *New results concerning the diurnal variation of atmospheric electricity*, was presented by Mr. S. J. MAUCHLY, and was illustrated.

It has long been known that for any given locality the electrical potential difference between the ground and a point in the air, say 1 meter above ground (potential gradient), varies throughout the course of the day in an approximately cyclical manner; also that the amount and nature of this variation is not the same for all localities, that some localities have two maxima and two minima during a 24-hour cycle while others have only a single "wave." Although various authorities have assumed that the occurrence of the principal minimum about 4 p.m. was a rather general characteristic for nearly all stations, Mache and Schweidler[1] long ago pointed out that the phase angle of the 24-hour wave varied greatly from station to station while the phase angle of the 12-hour wave was approximately the same for nearly all the stations. The results of the observations made aboard the *Carnegie* since 1915, representing about half the Earth's surface, indicate that the average diurnal variation of the potential gradient at sea is of the single-wave type, *i.e.*, most days show only one maximum and minimum. However, a much more significant fact is the indication that the time of maximum, or of minimum, is approximately the same over all the different oceans, occurring on a *universal* rather than local-time basis.

Observations for the diurnal variation of the number of positive ions in the air, and also those for the variation of the electrical conductivity of the air due to its positive ions, indicate that in general both these quantities are, over all oceans, above average value during the day and below average value during the night. But in both cases the average range found was of the order of only 10 per cent of the respective mean values, while for the potential gradient the average range was between 30 and 40 per cent of the mean value. Thus it turns out, on the basis of the *Carnegie* diurnal-variation data now available, that the computed vertical current density due to positive ions (and probably the total current density) is also subject to a diurnal variation in which a single wave predominates, whose chief maximum (or minimum) occurs approximately at the same universal time over all the ocean areas.

Attention was directed to the fact that the diurnal-variation curves for the potential-gradient derived from the *Carnegie* observations are very similar to curves which represent the relative frequencies of the aurora borealis as observed at several stations and also to curves representing the diurnal distribution of magnetic disturbances when all are referred to the same time basis. It was pointed out that owing to the non-coincidence of the Earth's magnetic axis with its axis of rotation, the time of daily potential-gradient maximum, as indicated by the ocean curves, corresponds approximately to

[1] H. MACHE and E. v. SCHWEIDLER. *Die Atmosphärische Electrizität*, p 27 (Braunschweig, 1909).

the time when the Earth's north magnetic pole, for example, is farthest from the sun. The actual times of maximum and minimum, however, appear to depend upon the positions of *both* magnetic poles and the fact that their longitude difference is not 180 degrees. These correlations support the assumptions of various investigators that the Earth's electric charge and resultant field may be very intimately related to an electric radiation from the Sun.

A more complete summary will appear in the current volume of *Terrestrial Magnetism and Atmospheric Electricity.* The paper was discussed by Messrs. C. A. BRIGGS, WHITE, and HUMPHREYS.

The third paper, on *New relations between terrestrial magnetism, terrestrial electricity, and solar activity* was presented by L. A. BAUER and was illustrated.

Connections between sun-spot activity, disturbances of the Earth's magnetism, earth-currents, and polar lights have been worked out by various investigators. The recent severe magnetic disturbances and earth-currents which accompanied a week ago the remarkable sunspot activity and brilliant display of polar lights have drawn renewed attention to the relationships between these four classes of natural phenomena.

The present paper shows that there is a fifth natural phenomenon—atmospheric electricity—with which an interesting and suggestive relationship with solar activity is exhibited. Owing to the many disturbances to which the atmospheric-electric elements are subject, as for example during cloudy and rainy weather, it has been difficult to establish the existence of definite variations of the chief atmospheric-electric elements during the well-known sun-spot cycle of somewhat over 11 years than in the case of magnetic effects, earth currents, and polar lights. The new results found are based upon atmospheric electric data obtained chiefly at four European observatories between 1898 and 1919, the combined data, in the case of the potential gradient, thus covering about two sun-spot cycles. Recent observations on board the *Carnegie* indicate a decrease in the electric potential-gradient since 1917, when sun-spot activity was at a maximum

The following chief facts have resulted

(1) The Earth's average intensity of magnetism, as well as the strength of the normal electric currents circulating in the Earth's crust, suffers a diminution during increased solar activity, *i.e.*, the currents induced in the Earth during periods of increased solar activity are in general reversed in direction to the normal currents, the strength of these superposed currents increasing with increased solar activity. The diurnal range of the strength of the normal earth currents, as in the case of the diurnal range of the Earth's magnetic elements, increases with increased sun-spot activity.

(2) The atmospheric potential gradient, or the deduced negative charge on the surface of the Earth, increases with increased solar activity, the range in the variation between minimum and maximum sun-spot activity being about 20 per cent. The electric conductivity of the atmosphere, on the other hand, shows but little, if any, systematic variation during the sun-spot cycle. Accordingly, since the vertical conduction current of atmospheric electricity is derived from the product of the potential-gradient and the electric conductivity, it is found that this vertical current increases in strength with increased solar activity. It would thus appear that atmospheric electricity, like terrestrial magnetism, is controlled by cosmic factors. The results derived here may have an important bearing upon theories of atmospheric electricity.

(3) Instead of using for short periods, as for example a month, the sun-

spot numbers direct for comparison with magnetic and electric variations, it is found that a more satisfactory measure of solar radiations and emanations affecting the Earth's magnetic and electric condition may be based upon the monthly range of sun-spot frequency, or upon some quantity indicative of the rate of change, or variability of sun-spottedness.

(4) A discussion of the sun-spot data for the period of 44 years, 1876–1920, confirms the existence of an annual periodicity in sun-spottedness, the minimum occurring about the time (January) when the Earth is nearest the Sun, and the maximum occuring on the average in July, when the Earth is farthest away from the Sun, the average difference between maximum and mimimum is about 6 sun-spot numbers. There would thus be given additional support to the view of planetary influence upon sun-spottedness.

(5) The electric potential-gradient, on the average, for both hemispheres shows a minimum value in July and a maximum in January; the annual range is about 50 per cent. On the other hand, the Earth's magnetic energy, as well as the strength of earth-currents, show on the average a higher value during the summer months than during the winter months for the northern hemisphere.

The paper was discussed by Dr. HUMPHREYS.

A more complete summary will appear in the current volume of *Terrestrial Magnetism and Atmospheric Electricity*

H. H KIMBALL, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Mr LOUIS V. DIETER has resigned as bacteriologist of the Health Department of the District of Columbia. He had been with the department since 1909

Dr. HENRY GORDON GALE, professor of physics at the University of Chicago, has been made chairman of the Division of Physical Sciences of the National Research Council, for the year ending June 30, 1922.

Captain ANTHONY FRANCIS LUCAS, retired mining engineer, died at his home at 2300 Wyoming Avenue on September 2, 1921, in his sixty-sixth year. Captain Lucas was of Montenegrin origin and was born at Trieste on September 9, 1855 He was for a number of years an officer in the Austrian navy He took an active part in the development of the oil and gas fields of the Gulf Coastal Plain, and was particularly interested in the geological problems of the origin of petroleum and the origin of the salt domes of Louisiana and Texas. He was a member of the Geological Society and the Society of Engineers

Mr. J. E. NOBLE has been appointed bacteriologist of the Health Department of the District of Columbia.

Dr GEORGE B. ROTH, pharmacologist with the Hygienic Laboratory of the U. S. Public Health Service, resigned in September to accept a teaching and research professorship at Western Reserve University, Cleveland, Ohio

Mr. CHARLES K. WEAD, for over twenty years an examiner in the U S. Patent Office in the Class of Music, has resigned, and will reside at Ann Arbor, Michigan.

Professor CHARLES E. WEAVER, non-resident member of the ACADEMY, has returned to the University of Washington at Seattle to resume his work as professor of paleontology, after a leave of absence of three years in Central and South America as geologist for the Standard Oil Company.

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PHYSICS.—*A furnace temperature regulator.*[1] HOWARD S. ROBERTS, Geophysical Laboratory, Carnegie Institution of Washington. (Communicated by Arthur L Day.)

In 1919 White and Adams described a temperature regulator for direct current resistance furnaces[2] in which the heating coil of the furnace was placed in one arm of a Wheatstone bridge and the heating current was varied by a motor-driven switch controlled by the galvanometer of the bridge. The switch opened or closed the circuit through a shunt around a fixed resistance in series with the furnace but outside the bridge. This arrangement causes the temperature of the source of heat (the platinum wire) to oscillate within rather narrow limits at such a rate that the oscillations in the temperature of a body within the furnace are imperceptible.

Regulators of the Wheatstone bridge type are particularly adapted to long narrow furnaces where the heating element covers nearly all of the surface of the cavity; their use obviates the need for placing any part of the regulator within the furnace, and there is no thermal lag whatever between heater and regulator as there is where the regulator employs a thermocouple placed inside the furnace.

The apparatus set up by White and Adams included a specially constructed galvanometer-relay, and it was with the primary idea of replacing the latter with stock apparatus that the present regulator was devised. Incidentally, the choice of a different type of galvanometer has overcome one rather serious defect in their apparatus.

DESCRIPTION OF THE REGULATOR

Figure 1 is a schematic diagram of the present regulator. It is intended for use with furnaces whose resistance when hot lies between 2.5 and 10 ohms, requiring not more than 15 amperes at 110 volts direct current. For heavier currents a different form of main relay is necessary.

[1] Received September 23, 1921.

[2] Phys Rev 14: 44–48 1919

The galvanometer *A* is essentially a millivoltmeter having a short contact arm or boom in place of the usual pointer, and two contact stops. It differs from the White-Adams instrument in that contact is made as soon as the boom reaches one or the other stop. *B* is an ordinary polarized telegraph relay, and *C* a "main line" telegraph relay. The main relay *C* is operated by current taken directly from the line through the resistance coils R_1 and R_2. It opens when its coil

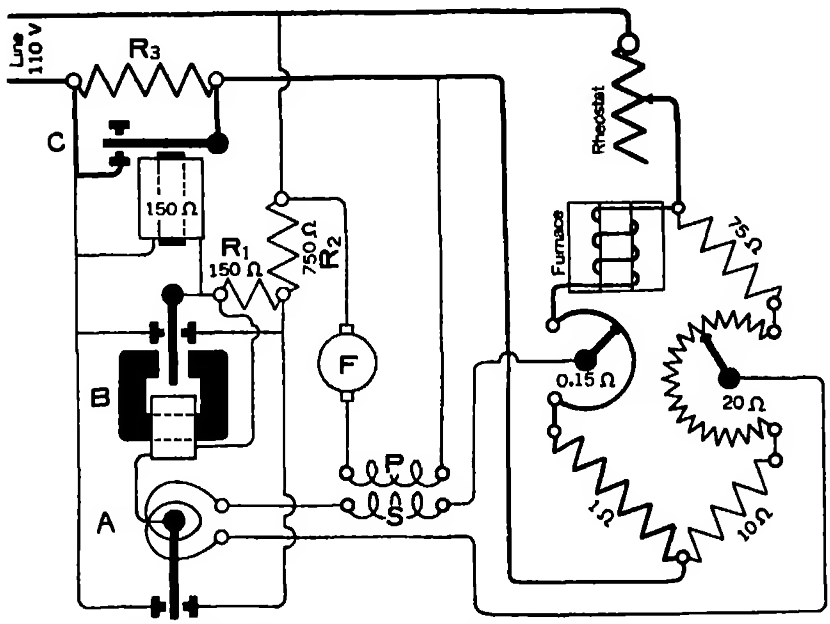

Fig. 1.—Schematic diagram of furnace temperature regulator

is short-circuited by the contacts of the polarized relay *B*. The galvanometer contacts are so connected that the movements of the galvanometer place the polarized relay *B* either in parallel with the main relay *C* or in parallel with 150-ohm resistance R_1. The operation of the polarized relay, however, immediately short-circuits the particular coil with which it has just been connected, thus stopping the flow of current through the contacts of the galvanometer.

This arrangement was intended to prevent these contacts from becoming welded together, but was found to be insufficient. Therefore, the secondary (low-voltage winding) *S* of a "bell-ringing" transformer was connected in series with the galvanometer, and the

primary P connected through a "thermal lamp flasher" F to the battery corners of the bridge. The operation of the main relay C increases or decreases the current through P and induces a momentary surge of current through the coil of the galvanometer. The current is caused to pass through the primary P in such a direction that this surge causes a rather violent deflection of the boom away from the contact stop.

The "lamp flasher" F also causes sudden changes in the current through P and corresponding deflections of the galvanometer, which occur independently of the movement of the relay. The violence of the deflection serves to make contact when the contacts have been brought together but have been prevented from touching by a chance accumulation of dirt.

CYCLE OF OPERATION OF THE RELAYS

In describing the various operations of the relays by which the regulator controls the temperature of the furnace we shall arbitrarily assume that a rise in the temperature of the furnace causes a movement of the boom of the galvanometer A toward the left, and that closing the galvanometer contacts to the left sends a current through the polarized relay B in such a direction as to cause its boom to move over to the left-hand contact.

At a given instant, let us say, the contacts of the polarized relay B are closed on the left; the main relay C is then short-circuited and open; the current to the furnace is passing through the resistance R_2, being cut down thereby to its lower value, and the furnace is therefore cooling.

As it cools, the boom of the galvanometer A moves toward the right, and when it touches the right-hand contact, completes a circuit through the coils of the polarized relay B in parallel with the resistance R_1. This causes the armature of the polarized relay to start to move over towards its right-hand contact. The main relay C is now no longer short-circuited, and closes, cutting out the resistance R_2.

When the armature of the polarized relay reaches the right-hand contact it short-circuits R_1 and thus stops the flow of current through its own coils and through the right-hand contacts of the galvanometer A Since it is a polarized relay, its armature does not swing away from the contact, but remains pressed against it because of the action of the permanent magnetic field of the relay.

With the resistance R_3 cut out, the temperature of the furnace rises and the boom of the galvanometer swings toward the left. When it reaches the left-hand contact it completes a circuit through the polarized relay in parallel with the coils of the main relay C, and the armature of the polarized relay moves over to the left hand contact. This short circuits the coils of the main relay C, whose armature drops back and restores the resistance R_3 to the furnace circuit. The action of the polarized relay B in short-circuiting the main relay C stops the flow of current through its own coils and through the left-hand contact of the galvanometer

The furnace is now cooling, the relays are in their original positions, and the apparatus continues to pass through repetitions of the same cycle which differ only in the time element.

DESCRIPTION OF THE RELAYS, ETC

The galvanometer A, in this particular apparatus, was obtained from the Weston Electrical Instrument Company; it has an internal resistance of about 50 ohms and a period of about $^2/_3$ second, and is provided with two fixed contacts and one movable contact, said to be of "iridium alloy." I have separated these contacts to allow room for the ballistic swing, caused by the bell transformer, so that they close at about plus and minus five millivolts. Experience has indicated that the instrument might better have a resistance as low as 10 ohms and a somewhat shorter period even if the sensibility were halved by the change The contact buttons need to be cleaned about once a day, and polished with fine emery cloth, or a carborundum stone, about once a month.

The polarized relay B of the ordinary telegraph or burglar alarm type is also provided with two fixed contacts. The coils are wound with Number 40 B & S. gage (0 08 mm.) copper wire to a resistance of 2000 ohms in order to reduce the current through the galvanometer contacts

The main relay C is of the ordinary telegraph type, wound to a resistance of 150 ohms It was found well worth while to replace the original silver contacts of this relay, as well as those of the polarized relay, with molybdenum.

The bell transformer is of the size designed to operate an electric bell from a 110-volt lighting circuit.

The "thermal lamp flasher" is a device which depends for its operation on the thermal expansion and contraction of a strip of metal

wound with a heating coil connected in series with the lamp. A suitable contact is arranged to short-circuit the heating coil when the strip has expanded to a certain point, whereupon the strip cools and the contact opens. This particular model is mounted in a tube provided with a lamp base at one end and a lamp socket at the other For the present purpose, a 60-watt, 110-volt lamp flasher, with a lamp in it, is placed in parallel with another lamp. The effect on the galvanometer may be adjusted by changing from one size lamp to another. A satisfactory combination of lamps in the present apparatus is one which causes the flasher to complete about four cycles per minute

A satisfactory value for the resistance R_3 is about $^1/_3$ the resistance of the furnace. The rest of the apparatus consists of switches and resistance coils and need not be described However, it may be pertinent to point out that the resistance wire used in the bridge should be of constantan, advance, ideal, manganin, therlo or some other alloy having a very low temperature coefficient of resistance, that the resistance coils should have ample current-carrying capacity; and that where copper connectors are used in the bridge, these should be short and of large cross section.

PRINCIPLES AFFECTING THE CHOICE OF A GALVANOMETER

This discussion applies particularly to resistance furnaces having a wire resistor wound on an insulating tube and imbedded in a thin layer of insulating cement, both tube and cement, as well as the wire, being good conductors of heat. The heating element as a whole is surrounded by a thick layer of loose magnesia or other nonconductor of heat. With this type of construction, the difference between the average temperature of the wire and that of the tube amounts at high temperatures to several degrees and adjusts itself much more quickly to changes in the heating current than does the temperature of the tube. Consequently, if the heating current is alternately increased and decreased at short intervals the temperature of the heating wire will oscillate through a considerable interval,[3] while that of the tube remains nearly constant.

The average temperature of a point within the furnace depends, among other things, upon the average rate at which energy is supplied to the furnace. Since the regulator must choose between two rates over whose value it has no control, it can only obtain the de-

[3] In the only case studied this interval amounted to at least 2° C with a half period of about one second.

sired average value by adjusting the ratio of the length of time the one rate is being supplied to the length of time the other is being supplied. In the case of a galvanometer having mechanically operated contacts, the circuit may only be closed at particular instants separated by arbitrarily fixed time intervals. Consequently, the ratio referred to must be approximated by a fraction whose numerator and

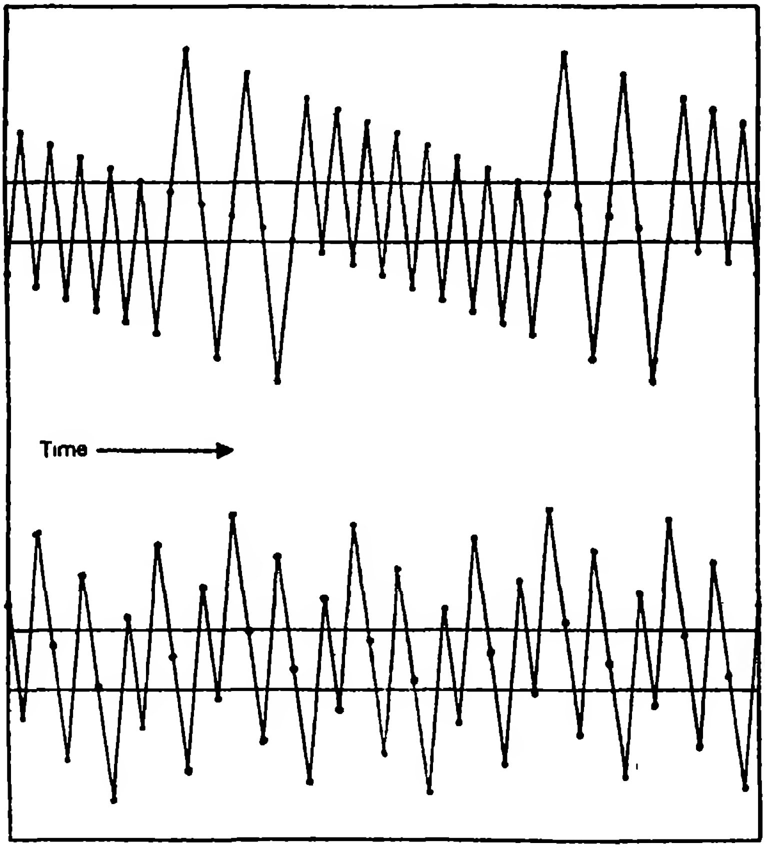

Fig. 2 Diagram to illustrate the periodic fluctuations in temperature of a furnace controlled by a galvanometer having mechanically operated contacts

denominator are integers. This may consume a considerable number of time intervals and allow considerable fluctuation in the temperature of the furnace tube.

An attempt has been made to show this graphically in figure 2. The wavy line represents the excursions of an idealized galvanometer

boom, while the strip between the parallel lines represents the zone in which the boom may lie without causing a movement of the switch. The black dots indicate the positions of the boom at the instants when the mechanically operated contact mechanism is depressed The ratio of heating time to cooling time in the upper diagram is 13 12 and there is a slow, cyclic variation in temperature extending over 25 of the equal time intervals. In the lower diagram, where the ratio is 19:31, this slow variation is much less serious Decreasing the time interval between the successive instants at which contact can be made would undoubtedly improve matters greatly, even if the period of the galvanometer could not be decreased.[4]

The galvanometer with fixed contacts, as used in the present apparatus, is free from this restriction and may make contact at any time Neither type of galvanometer follows the temperature of the heater very closely; the inertia of the moving coil causes a considerable lag which, however, seems to do no harm

The regulator has thus far been used only on direct current furnished by a battery or generator. The pulsating direct current furnished by a mercury arc rectifier causes the galvanometer to vibrate seriously because of the alternating current induced in the bell transformer by the pulsations. Several plans have suggested themselves to make it operate on alternating current partially rectifying the current with an aluminum cell, putting a 6-volt storage battery in series with the source of supply; or making an alternating-current galvanometer. In any case, it would be necessary to operate the bell transformer from a separate source of direct current, or to adopt some other scheme, such as rotating the galvanometer contacts, in order to prevent their sticking. The alternating-current galvanometer has seemed most hopeful and one is now under construction.

Although the foregoing discussion has confined itself to discussing the regulator in combination with a particular type of furnace, there is nothing to prevent the same principles from being applied to other purposes, such as baths of oil or molten metal, or even gas fired furnaces, since it is not necessary to use any part of the bridge as a heater.

PERFORMANCE

When it is used with platinum resistance furnaces at temperatures below 1250° C., this regulator has been found to maintain the

[4] A recent experiment indicates that this interval may be decreased to $^1/_3$ second by a suitable design.

temperature constant within ± 0.1° C. for hours without any attention. At higher temperatures the furnace cools slowly, 2 or 3° per hour at 1450°. This cooling, which is perfectly regular, is undoubtedly due to slow changes in the furnace for the resistance of the heating coil is held constant by the regulator. The cooling can be compensated for by an occasional manual adjustment of the slide wire contact on the bridge.

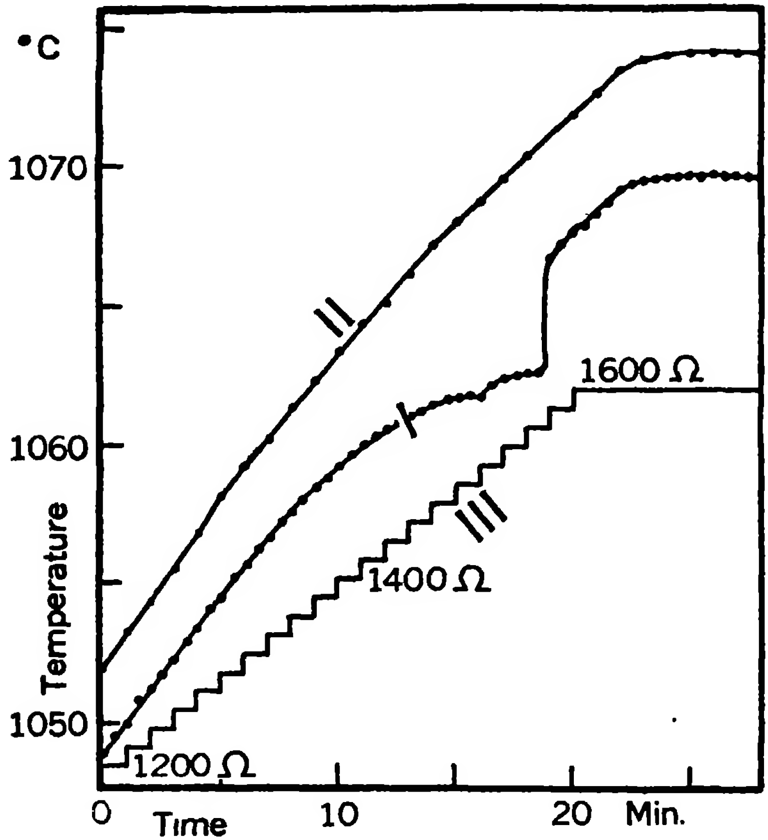

Fig. 3. Curves to illustrate the performance of the regulator in the steady heating of the furnace to determine a melting point

In a particular experiment, a platinum wound furnace of the type described was being maintained by the regulator at 1269°. Its resistance at this temperature was 9.9 ohms. The galvanometer contacts were set to close at ± 5 millivolts, corresponding to a change of about ± 1° in the temperature of the heating wire. With the rheostat adjusted so that the times of heating and cooling were approximately equal, and the current 10.0 and 7.3 amperes respectively,

the relays operated 59 times per minute. When one ohm more resistance was put in, causing the current to fall to 9.3 and 6 9 amperes, the relays operated 38 times per minute, and the temperature within the furnace fell only 0 1°. This change in the heating current corresponded to a fall of about 6 per cent in the line voltage, about as large a fluctuation as is likely to occur in the voltage of a lighting circuit.

ATTACHMENT FOR STEADY HEATING OR COOLING

If the furnace is to be used in making heating or cooling curves, the adjustment of the regulator must be changed either continuously or by small, frequent steps. The slide wire of the Wheatstone bridge may be used for this, but it has been found more convenient to shunt the 75 ohm coil of the bridge with a rheostat giving steps of 10 ohms from 1000 to 2000 ohms, placed beside the potentiometer used for measuring the furnace temperature A 10 ohm slide wire rheostat is included in the circuit and used as an alternate fine adjustment for work at constant temperature.

Figure 3 is the heating curve obtained from the melting of a small sample of gold in calibrating a thermocouple Curve I is the temperature of the gold, II, that of a thermocouple placed a little above it, and III, the resistance in parallel with the 70 ohm coil of the bridge The heating curve, II, of the furnace is not linear, but it is smooth, and the curve, I, furnished by the sample of gold is entirely satisfactory

A linear heating or cooling rate can be obtained by means of a simple potentiometer connected in series with the galvanometer.

TECHNOLOGY —*Radiators for aircraft engines*[1] S R PARSONS AND D R HARPER, 3D, Bureau of Standards

The technologic paper from which this article is condensed will describe the laboratory investigations relating to aircraft engine radiators which were conducted by the Bureau of Standards during the World War and in the two years immediately succeeding it Individual reports covering many phases of the subject have been published previously in the technical series of the National Advisory Committee for Aeronautics and in scientific and engineering journals. These reports, however, lack the systematic coordination, uniform terminology, and unified mathematical treatment which should

[1] Condensed from a forthcoming official publication of the Bureau of Standards, U S Department of Commerce. Communicated by the authors with the permission of the Director of the Bureau of Standards. Received September 24, 1921.

characterize a handbook on the subject. Moreover the problems which were investigated first because of their greater importance and which were the subjects of the reports published earliest, are for that reason not so well covered as is now possible because the later work threw much additional light upon matters not settled at the time of publication of the early reports Accordingly, the present paper is much more than a reprint of earlier reports, being a complete revision and recompilation of the material available.

The special investigations reported included development of the methods of measuring air flow in radiator tubes, experiments upon the effect of nature of surface upon air flow and upon heat dissipation from the surface of metal tubes to a high velocity air stream; experiments to ascertain the degree of turbulence in the air tubes of a radiator core; mapping of temperature distribution, axially and transversely, in the air tubes of radiator cores In addition to recording these special investigations, the paper contains a full description of laboratory methods and instruments for those tests of radiator cores properly made in the laboratory both of physical properties and geometrical characteristics such as size and shape of air tubes and of water tubes

The work included laboratory measurements of cooling power, head resistance, and geometrical characteristics of over one hundred types of radiator core. These data are tabulated in an appendix and the performance characteristics of 66 types of core are given in graphical form. The general conclusions from these measurements and from the special laboratory experiments mentioned above are incorporated into an exposition of the fundamental relations between the conditions under which a radiator operates, its characteristics of form and construction, and the properties which describe its performance. This portion of the designer's field is by no means the whole, however, and the paper does not treat the important considerations of sturdiness, ease of construction and repair, cost, form of design imposed by the structure of the aircraft, etc.

The heat-dissipating power of a given type of core construction was found to be specified completely when the mass rate of air flow was specified. It makes no difference whether a given mass rate is obtained by high velocity and low density or low velocity and high density, a relation which was studied in some detail because of its significance in respect to behavior of aircraft radiators at high altitudes of flight. The empirical relation

$$H = bM^nT$$

(where H is heat dissipated per unit time per unit frontal area of core, M is mass of air per unit area per unit time through the air tubes of the core, and T is difference between the average temperature of the water in the radiator and the temperature of the air at entrance to the core) was found to hold for all ordinary types of core construction, b and n being constants pertaining to any particular core. The numerical value of n was usually in the neighborhood of 0 8, indicating that the relationship between heat dissipation and air flow through the core of a radiator is not far from the relationship of direct proportionality, although too far to assume such a relation over any considerable range of air flows.

A second equation for computing the cooling power of a core is

$$H = C_pMT\ (1 - e^{-\alpha x_1})$$

where H, M, T have the significance quoted in the preceding paragraph, e is the logarithmic base 2 718, C_p is specific heat of air at constant pressure, x_1 is the depth of the radiator core (dimension parallel to air flow) and α is a constant for a given core and given air flow through it. Since a chosen value for α permits no latitude in air flow, or in changing core construction, the equation in this form is intended primarily for study of the effect upon cooling power of changing the depth of core. Giving due consideration to head resistance as a function of frontal area and depth, the formula permits computation of the optimum depth of radiator for given conditions. For very high speed flight, it is advantageous to use cores much deeper than was the common practice in early days of airplane development, 8 to 10 or 12 inches depth being desirable for some types of the usual quarter inch to half inch air tube core, in unobstructed positions.

The formula just quoted is not entirely empirical in its origin, but has a rational basis. The assumptions underlying it are plausible and it is not surprising to find that in applying it to results of measurements with almost all common types of core these results are represented very well. The parameter α is an abbreviation for pq/MC_p, where M and C_p have their former significance, p is total perimeter of the air tubes in unit frontal area, provided the cooling surface is all direct surface (and an equivalent value for the cases where part is indirect cooling surface); q is the cooling coefficient between the metal and an air stream of velocity corresponding to M, namely, q is heat transferred per unit time per unit area of metal per degree tempera-

ture difference between the metal and air flowing past it. The numerical values of q were found to agree very well with values computed from a formula given by Stanton and Lanchester:

$$q = \frac{C_p R_f}{V}$$

and by Lees

$$R_f = \rho V^2 \left[0\ 0765 \left(\frac{\mu}{V\rho D}\right)^{0\ 35} + 0\ 0009\right]$$

the comparison being made for radiator cores with smooth round and square and hexagonal air tubes, nearly all direct cooling surface. The formulas given were originally stated for long circular cylindrical tubes with smooth walls, C_p being specific heat of air at constant pressure, V the velocity of the air through the tube, ρ its density, and μ its viscosity. R_f is the surface friction, or force per unit surface between the air stream and walls of the tube, and D is tube diameter.

The above formulas may be combined into a single expression (making some reductions not given here in detail), so as to compute heat dissipation of a core from its dimensions, and for simple type regular cellular cores it seems highly probable that results will be reliable within 10 per cent

$$H = MC_pT\ (1 - e^{-\alpha x_1})$$

$$\alpha x_1 = \frac{x_1}{r}\left[0\ 0471\left(\frac{a\mu}{rM}\right)^{0\ 35} + 0.0009\right]$$

H = heat dissipated, units of power per unit frontal area of core,
M = mass of air per unit time per unit frontal area,
C_p = specific heat of air at constant pressure,
T = temperature difference water and air entering core.

Any consistent set of units whatever may be used for the above four quantities, but care must be exercised to avoid any inconsistencies; *i e* , the heat units for H and C_p must match, the mass units for M and C_p, the area unit for H and M, etc The same is true for the following sets of quantities, although the units for these need not be the same as the first set.

x_1 = depth of radiator core, in same units as r,
r = hydraulic radius of air tube (quotient of area by perimeter),
M = mass of air per unit time per unit frontal area,
μ = viscosity of air in a unit consistent with M and r,
a = free area of core; the ratio of the total cross section of the tubes to the frontal area. (Being a ratio it is independent of units.)

The laboratory measurements of heat-dissipating power were made with two sources of heat, steam and hot water. For superheated steam, the effective temperature is computed by weighting properly the heat derived in each stage (loss of superheat, condensation, cooling of water):

$$T_m = \frac{\left(T_c + \frac{S}{2}\right)C_p\,S + T_cL}{C_pS + L}$$

where T_m is mean effective temperature, T_c is temperature of condensation, S is superheat (in degrees), L is latent heat of condensation and C_p is specific heat of superheated steam. The condensate was usually not cooled significantly below the temperature of condensation and the formula above is in the simplified form resulting from neglecting such cooling. An intercomparison of test data on ten cores, using both superheated steam and hot water as sources of heat for the calorimetric measurements, showed that no appreciable difference existed between the results obtained by the two methods. A series of measurements using water as the source of heat were made with the rate of water flow varying over a wide range. As might be expected, a wide range of variation of heat dissipation occurred with change of rate of water flow when the rates were extremely low, but at the rates of flow common in radiator use, the effect was not significant. It seems safe to assume that heat dissipation for conditions all constant except rate of water flow will attain a value within 5 per cent of the maximum which it will reach with any rate of flow, if the rate be as much as 3 gallons per minute per inch depth of core 1 foot wide. This flow is well within the margin of circulation found in most aircraft cooling systems.

The effectiveness of indirect cooling surface, namely, cooling surface not backed by flowing water, is considered in detail and the mathematical relations are developed which describe its behavior. The effectiveness of indirect surface is defined as the ratio of its heat-dissipating power to that of an equal area of direct cooling surface all at the temperature of the edge of the indirect surface which has contact with the source of heat. For long narrow fins such as the indirect cooling surface found in a square cell or hexagonal cell construction, the effectiveness is

$$E = \frac{\tanh U}{U}$$

where U takes the form

$$U = b \sqrt{\frac{2q}{yk}}$$

b is the width of fin where good thermal contact[2] occurs along one edge of the fin only, and is half the fin width where good thermal contact is made by both parallel edges. The fin thickness is y and the thermal conductivity k, the quantity q being the surface heat dissipation coefficient in units consistent with k and the dimensions b and y For the combinations of values usually occurring in radiator practice, the effectiveness exceeds 70 per cent and quite commonly averages 85 per cent to 95 per cent. The formula was applied to calculate optimum dimensions for fins under various conditions, the results being tabulated The equations of thermal conduction are also used to compute a table of temperature drop through water-tube walls of various thickness and materials

A considerable amount of detail not suited to abstracting is to be found in short notes on such topics as effect of yaw on performance, slipstream mountings, wing radiators, shuttering, radiator requirements at altitude and methods of computing performance at altitude from test data obtained at ground level. A brief treatment is included of the subjects of partially streamlined casings to enclose a radiator, and of nose mounting

From the point of view of an airplane designer, it is desirable to specify radiator performance in terms of flying speed of the plane. In general this cannot be done directly because too many factors are involved in the relation between flying speed and the air flow through the radiator core. It becomes necessary, therefore, for describing characteristics of the radiator, to adopt air flow through the core as the prime variable, there being no other quantity or entity available for the purpose The ease or difficulty of applying such a description of performance to plane design rests then with the difficulty in estimating the probable air flow through the core for given flying speed. For a radiator mounted in an unobstructed position the difficulties are inappreciable, the estimation process is replaceable by actual measurement and the results are obtainable with satisfactory accuracy. For a nose mounting, or other obstructed position too many factors enter into the determination of the air flow to make generalizations possible. Consequently, the authors are unable to include in the paper material

[2] Soldered or integral metal Mere contact, unsoldered, of two pieces of metal is thermally a discontinuity

of direct application, without any intervening step, for the nose radiator, a mounting which is today probably the most common in American practice. The designer who is interested in such a mounting must first secure a measurement or estimate of the air flow to be expected in the core of his radiator, taking into account the size and shape fuselage, engine, propeller, and all the objects which will determine this air flow, and then with such data in hand he can apply all the results of this paper.

The paper is carried one step beyond expressing radiator performance in terms of air flow through the core, and states the results of the measurement in terms of flying speed for a mounting in an unobstructed position. Comparative performance is stated in terms of figure of merit which is the ratio of the power dissipated as heat to the power required to sustain the weight of the radiator and overcome its head resistance in pushing it through the air The relative figures of merit of two cores in an unobstructed position do not, of course, furnish an index of value in an obstructed position. The comparative behaviors of various classes of core are discussed in some detail for the unobstructed position and it is shown that for this mounting and high speed of flight, the flat plate core construction has a figure of merit sufficiently above other types to deserve attention. Its chief disadvantage is inherent mechanical weakness, a feature of extreme importance in selecting a design for use, and the data presented should afford the designer definite information regarding the sacrifice in figure of merit which must be balanced against increased sturdiness, when choosing between types of core.

For flying speeds of 60 to 200 miles an hour' it seems certain that an unobstructed radiator plus a streamline nose to the fuselage offers a figure of merit so much above that of a nose radiator installation as to justify considerable effort toward overcoming the structural difficulties attendant upon such a mounting

The measurements made on a very wide range of variety of cores indicate that vanes, holes in the air-tube walls, and all devices intended to ncrease turbulence in the air tubes are detrimental to radiators in an unobstructed position, lowering the figure of merit for a given flying speed. The effect is to decrease the air flow more than is compensated by the increased heat-dissipating power at a stated rate of air flow. On the other hand, in obstructed positions, where the air flow is determined more by the radiator surroundings than by its own core construction, the cores with turbulence devices

may be advantageous. For regularly shaped cellular tubes, with straight walls, parallel to the wind, and with no vanes or holes, an empirical formula was developed which was found to express air flow through the core in terms of flying speed, with a surprising degree of accuracy:

$$m = a\left(1 - 10^{\frac{-44r}{x}}\right)$$

where r is hydraulic radius of an air tube (quotient of cross section by perimeter) and x is depth of the core (length of an air tube), both these dimensions being measured in the same unit of length; a (the free area of the core) is the ratio of the total cross sectional area of the air tubes in a given frontal area to that frontal area; m is the air flow constant, the fractional part of the air flow approaching the core which passes through it, hence, unity minus the fractional part deflected around the core. In a wind stream of 5 pounds per second per unit area, a core of unit frontal area which transmitted 3 pounds of air per second and deflected the other 2 around it, would have an air flow constant of 0.60. The presence of headers or water boxes would modify the direct application of the formula to a radiator since the formula is for a core alone, but with the exercise of suitable judgment in making an allowance for water boxes and connection piping, it should be possible, from the geometrical characteristics of a simple core, to compute with a satisfactory degree of accuracy the air flow which would correspond to any stated flying speed with the core in an unobstructed position.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

GEODESY.—*Radio-compass bearings*. OSCAR S. ADAMS. U. S. Coast and Geodetic Survey Spec. Publ. 75. (Serial 167.) Pp. 39. 1921.

The radio-compass is coming into very general use for the determination of the positions of vessels at sea. For this reason, it seemed advisable to investigate the methods of plotting bearings thus obtained, both on the Mercator projection and on the gnomonic projection. In investigating the subject it is sufficiently exact to consider the earth as a sphere. It is further assumed that the path of the wireless wave over the surface of the earth is a great circle, joining the position of the vessel with that of the radio-compass station.

A straight line on a Mercator projection represents a rhumb line and not a great circle. A great circle on this projection is represented by a curve

which is concave towards the equator. If an observed bearing is laid down upon such a projection without correction, the line so determined is a tangent to the great circle curve at its point of origin, because the Mercator projection is conformal. This publication gives a mathematical derivation of the correction that must first be applied before the bearing is plotted on the projection. A practical method is then devised so that the required correction may be determined by means of three graphic charts with as small an amount of effort as possible.

For convenience in application the description of the practical use of the method is given first in the publication and the theoretical discussion is given in the final part of the same for the benefit of those who may be interested in this phase of the matter. A Mercator projection table for the sphere is also included as it is of use in connection with the graphic charts, one of the arguments for the same being obtained from it.

On the gnomonic projection a great circle is represented by a straight line, but the angle at the station is not preserved. It is necessary then for any particular gnomonic chart to have a table computed for each radio-compass station that gives the angles that must be laid off on the projection in order that the straight line may represent the great circle with any given observed bearing upon the earth. In this publication, tables are given for ten radio-compass stations along the eastern coast of North America, based upon the U.S. Hydrographic Office Chart No. 1280. O. S. A.

PHYSICS.—*The annealing of glass.* L. H. ADAMS and E. D. WILLIAMSON. Journ. Franklin Inst. **190**: 597–631, 835–870. 1920. (Geophysical Lab. Papers on Optical Glass, No. 32.)

It is shown that the process of annealing glass can best be carried out if we know for the various glasses and for the various temperatures the rate of release of the internal stresses. The results of such measurements for nine kinds of glass are presented. The release of stress at constant temperature was found to proceed usually according to the equation

$$\frac{1}{F} - \frac{1}{F_0} = A\,t$$

in which F is the stress at any time, t, F_0 is the initial stress, and A is a constant for the particular glass at a particular temperature, and is a measure of the rate at which stresses are relieved. The variation of this rate with temperature follows the equation

$$\log A = M_1\theta - M_2$$

in which M_1 and M_2 are constants for a particular glass and θ is the temperature.

At any temperature, a glass requires a certain *annealing-time.* This is arbitrarily defined as the time required to reduce the stress (in optical units) from 50 to 2½ $\mu\mu$ per cm. For convenience of reference, the 150° interval of temperature lying immediately below the temperature at which the annealing time is 2 minutes is called (also quite arbitrarily) the *annealing range.* At temperatures below the annealing range as thus defined, very little permanent stress can be introduced.

Concrete directions are given for annealing optical glass. The procedure to be followed for other kinds of glass, such as plate glass, bottles, chemical glassware, etc., is also indicated. Mathematical analysis of the problem shows

that the best method for annealing requires that the glass be held at constant temperature (below the customary annealing point) for the appropriate time and then cooled at an increasing rate. It is of interest to note that the larger the piece of glass the lower the annealing temperature. Finally, there are presented a number of equations which are convenient for calculating the internal stresses due to heating or cooling solids of various shapes.

While the original object of this investigation was to put on a quantitative basis the operations connected with the annealing of glass, it was found that many of the results have an important bearing on certain problems of geophysics. Thus, for example, the relief of internal stresses in glass probably belongs in the category of elastico-viscous flow and is thus connected with such processes as the tidal deformation of the earth's crust. Moreover, the formulas expressing the relation between temperature-differences and stress distribution are directly applicable to the phenomenon of the "jointing" of rocks L. H. A. and E. D. W.

GEOLOGY.—*Oil possibilities in and around Baxter Basin, in the Rock Springs uplift, Sweetwater County, Wyoming.* ALFRED REGINALD SCHULTZ. U. S. Geol. Survey Bull. 702. Pp. 107, pls. 17, figs. 9, inserts 3. 1920.

The data for this report were collected in 1907 and 1908 while the area involved was being mapped for its coal resources, and are now made available to meet the demand for information about oil and gas resources. As a consequence the report lacks the detailed information, especially the structure contour maps, usual in reports on this subject, but makes up for that deficiency by the fullness of the information on larger structural features, stratigraphy, oil shales, oil and gas bearing formations, etc. that is brought together for this and surrounding regions. Drilling for oil and gas was active in the Baxter Basin about 1900 but yielded mainly small amounts of gas. A recent revival of drilling had at the time of the report also struck mainly moderate flows of gas and little oil. Land surveys and geography are briefly discussed, and water supply somewhat more fully. In general water supply is poor except that available from deep artesian sources. Sixteen pages are given to a discussion of stratigraphy with detailed description of the principal exposed units which extend from the Baxter shale near the base of the Montana to the Eocene-Green River formation. Valuable correlation tables bring out the naming and subdivision of the entire section down to the pre-Cambrian at various times in this and adjacent areas. Twelve pages devoted to structure in conjunction with the geological map define the principal lines of folding, faulting, and overthrusting and their relation to the adjacent Uinta Mountains. Fifty-foot structure contours on the Rock Spring anticline are the only ones on the map, and it is only in relation to this structure that the possible localization of oil or gas accumulations is disscused.

A conspicuous feature of the report is the general review of the oil shale situation. In the area under discussion oil shale occurs in two portions of the Green River formation. Very full sections of this formation bring out the position of the oil shales; and the character of the beds, their oil content and so forth is discussed. A brief review with map shows the known reserves of oil shale in Wyoming, Colorado, and Utah. There follow 13 pages of discussion of the beds from the lower Montana to the Cambrian that might be reservoirs or sources of oil. The discussion is based mainly on evidence from adjacent areas and is accompanied by a valuable table showing the beds that yield oil and gas in various surrounding Rocky Mountain fields. The

remaining 21 pages of the bulletin are given to a rather detailed account of previous drilling in or near Baxter Basin, that is, mainly on the Rock Springs dome, with brief discussion of the beds that would probably yield oil and of analyses of oils from nearby fields. The author believes that the Frontier sandstones and the Aspen formation, both of which are at the base of the Upper Cretaceous and which in most of the area would be reached at depths of from 2000 to 4000 feet, will prove to be the principal oil-producing beds.

MARCUS I. GOLDMAN.

GEOLOGY.—*Coal in the middle and eastern parts of San Juan County, New Mexico.* CLYDE M. BAUER and JOHN B REESIDE, JR, U. S. Geol. Survey Bull. 716-G. Pp 82, pls. 19. 1921

This report describes briefly the geography and geology of San Juan County, New Mexico, and in detail the coal deposits of the middle and eastern parts. The geologic section includes 9 formations assigned to the Upper Cretaceous and 4 formations assigned to the Eocene. Coal occurs in 2 Upper Cretaceous formations—the Menefee formation of the Mesaverde group and the Fruitland formation. The coal beds of the Menefee formation are in 2 groups, one in the lower part of the formation and one in the upper part, with a barren interval between. Individual beds are lenticular and very variable in thickness and composition. The coal beds of the Fruitland formation are usually grouped in the lower part of the formation and are more persistent and thicker than those of the older Menefee formation. The number of beds and the quality of the coal decreases from north to south. The coal of both formations is of bituminous rank in the northern part and of sub-bituminous rank in the southern part of the county. The total quantity of coal is large but under present conditions will be developed for local use only. J. B. R

GEOLOGY.—*The iron-ore resources of Europe.* MAX ROESLER. U. S Geol. Survey Bull. 706. Pp. 152. 1921.

This bulletin, which is the outgrowth of a report compiled by the U. S Geological Survey for use at the Peace Conference, is the result of the study of a wealth of literature by many writers in many languages. The author has attempted to reduce the available information to nearly common scale, and to present briefly the distribution, character, and extent of the deposits in the various countries of Europe. The graphic review of the deposits is preceded by a brief sketch of the nature and geology of iron-ore deposits in general and a few notes on the methods of utilizing the ores. The production and consumption of the principal countries is given. The report contains many maps and diagrams and an extensive bibliography. R W. STONE.

GEOCHEMISTRY.—*Chemical researches on sediments.* H. E. MERWIN. Bull. Geol. Soc. Amer. 31: 419–424. 1920.

A general discussion of various phases of the chemical problems connected with the study of sedimentary rocks. The problems are difficult because of the complexity of the chemical solutions, the small solubility and lack of definite crystallinity of many of the substances, and the persistence of unstable phases. Diffusion in the solid state, consolidation under differential stress, adsorption, slow reactions, and effects of catalysis are discussed both in general terms and in their relation to the formation of dolomite and phosphate rocks and the oceanic red clay. H. E. M.

GEOCHEMISTRY.—*The chemistry of the Earth's crust.* HENRY S. WASHINGTON. Journ. Franklin Inst. 190: 757–815. 1920.

The number of essential rock-forming minerals is very small. They are mostly silicates of Al, Fe, Mg, Ca, Na, and K. Any two or more of these minerals (with two exceptions) may occur together and in all proportions. The chemical characters of igneous rocks are summarized in the paper and the ranges and maxima of the various constituents are given. The average igneous rock is considered and, after some discussion of the sources of error involved in the calculation, a new average (based on 5179 analyses) is given. The average rock is shown to be approximately a granodiorite. The average composition of the Earth's crust in terms of elements is also given. Twelve elements (O, Si, Al, Fe, Ca, Na, K, Mg, Ti, H, P, and Mn) make up 99.61 per cent of the crust.

The elements are referred to two main groups in the periodic table: (1) the petrogenic elements, characteristic of and most abundant in igneous rocks, of low atomic weight and occurring normally as oxides, silicates, chlorides, and fluorides, (2) the metallogenic elements, rare or absent in igneous rocks, but occurring as ores, of high atomic weight, and forming in nature metals, sulfides, arsenides, etc., but not oxides or silicates. The suggestion is made that beneath the silicate crust of petrogenic elements is a zone essentially of nickel-iron, and beneath this a central core of the metallogenic elements. This vertical distribution is in accord with Abbot's views as to the distribution of the elements in the Sun.

In igneous rocks and minerals the elements show a correlation, in that certain of them are prone to occur with others, and a similar limited correlation is apparently true of the animal and vegetable kingdom.

The idea of "comagmatic regions," that is, the distribution of igneous rocks in regions of chemically related magmas, is discussed, and some of these are briefly described.

The calculation of rock densities from their chemical composition is discussed, and the average chemical compositions and densities of the continental masses and oceanic floors are given. It is shown by these that the average densities of the continents, ocean floors, and various smaller regions of the earth stand in inverse relation to their elevations. The bearing of this relation of average density and elevation on the theory of isostasy is pointed out, and it is shown that the data presented are confirmative of the theory.

H. S. W.

VOLCANOLOGY.—*Two gas collections from Mauna Loa.* E. S. SHEPHERD. Bull. Hawaiian Volcano Obs. 8: 65–67. 1920.

Through the courtesy of Dr. T. A. Jaggar, Jr., of the Hawaiian Volcano Observatory, two tubes of gas were received which he collected in November 1919 from the flow on Mauna Loa. These are the first gases collected at this volcano. Dr. Jaggar had great difficulty in finding a suitable source for collecting, and greater difficulty in approaching it. The analysis of the gases accounts for part of the difficulty, since they show 2 and 8 per cent of SO_3 respectively. The combustible gases had practically all disappeared and the samples may be regarded as completely burned. It will be noted, however, that the amount of nitrogen present is not high and could not possibly account for the amounts of water present, namely, 67 and 75 per cent respectively. The argon group is present in rather larger amounts than at Kilauea, but amounts to a maximum of only 0.6 per cent. Free sulfur and chlorine were absent. Compared with similarly oxidized gases from

Kilauea, the Loa gas seems entirely similar in composition. The analyses, in volume per cent at 1200° and 760 mm., are given in the table below.

CO_2	3.84	6.42
CO	0.03	0.19
H_2		0.01
SO_2	1.22	1.95
SO_3	2.08	8.12
S_2		
Cl_2		
N_2	16.80	15.30
A	0.58	0.42
H_2O	75.44	67.43

E. S. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

342D MEETING

The 342d meeting of the Geological Society of Washington was held at the Cosmos Club at 8 p.m., on Wednesday, January 28, 1920.

Regular Program

G. R. MANSFIELD: *Types of structure in Southern Idaho.* (Illustrated.)

F. E. MATTHES: *Physiographic history of the Yosemite region.* (Illustrated.)

W. TAYLOR THOM, JR.: *The structure of the so-called Poplar Dome in northeastern Montana.*

343D MEETING

The 343d meeting was held at the Cosmos Club at 8 p.m., February 11, 1920.

Informal Communication

LAURENCE LAFORGE spoke on the correct use in physiography of the terms *mature* and *maturity*.

Regular Program

H. W. CORNELL: *Constitutional questions involved in the statutory classification of mines and minerals for purposes of taxation.*

M. R. CAMPBELL: *Abandoned meanders of James and Potomac Rivers and their bearing on Coastal Plain history.*

SPECIAL MEETING

A joint meeting with the Washington Academy of Sciences was held in the auditorium of the Cosmos Club at 8:15 p.m. on Thursday, February 19, 1920. The occasion was a lecture by ALFRED H. BROOKS on *The application of geology to war.* An abstract of the lecture has been published with the Proceedings of the ACADEMY in this JOURNAL.[1]

344TH MEETING

The 344th meeting was held at the Cosmos Club at 8 p.m., on Wednesday, March 10, 1920.

[1] This JOURNAL, 10: 331–333. 1920

Informal Communications

DAVID T. DAY spoke on some substances extracted from oil shale.

R. C. WELLS spoke on a deposit of aragonite on the inside of a sealed glass tube containing a standard sample of sea water. This communication has since been published in the JOURNAL.[2]

Regular Program

F. C. CALKINS: *Thrust faulting in the Cottonwood District, Wasatch Mountains, Utah.*

The thrust faults discovered in the Cottonwood district during 1912 by Loughlin and Butler and independently by Hintze dip in general eastward and hence were naturally supposed at first to have been caused by westward overthrusting. Recent field study, however, has brought out the following facts. (1) The main thrust plane dips westward in part. (2) The eastward dip is in places steeper than it could have been at the time the thrust-faulting occurred, so that some eastward tilting must have taken place; this tilting may well have sufficed to reverse an original low dip to the westward. (3) Most of the drag folds associated with the thrust faults indicate an eastward drag. It is therefore believed that the overthrusting was mainly eastward though a little westward thrusting may have taken place later.

The Cottonwood district lying at the intersection of the Wasatch and Uinta axes and affected by the stresses that caused the birth of both ranges is a favorable place for determining the position of the overthrusting in the history of the region. The order of the early events in that history is believed to be as follows:

At the close of the Mesozoic the site of the Great Basin, instead of being depressed relatively to the region at the east, was largely dry land, and the site of the Wasatch and Uinta Mountains formed part of an area of sedimentation. Deformation of the off-shore sediments began with "Wasatch" folding on north-south axes. This was followed by thrusting of the land mass over the lower basin at the east. Further movement in the same sense caused the thrust faults to be bent into folds whose axial planes lean eastward. The east-west uplift which gave rise to the Uinta Range, and which was accompanied or closely followed by the intrusion of granitoid rocks under the crest of the Uinta arch, was antedated by the overthrusting and probably by most of the north-south folding that affects the thrust planes. The thrust-faulting can therefore hardly be more recent than the end of the Cretaceous

SIDNEY PAIGE: *Interpretation of the Moon craters.*

KIRK BRYAN: *Mountain pediments. A discussion of the erosion of desert ranges.*

345TH MEETING

The 345th meeting was held at the Cosmos Club at 8 p.m., on Wednesday, March 24, 1920.

Informal Communication

MR. DAVID WHITE exhibited some highly polished chert pebbles found in residual clay of limestone in Missouri.

Regular Program

LEON DOMINIAN: *Geography of Asia Minor.* (Illustrated.)

H. S. WASHINGTON: *The chemistry of the Earth's crust.* (Illustrated.) This paper has been published in full.[3]

[2] R. C. WELLS. This JOURNAL, 10: 249–254. 1920.

[3] H. S. WASHINGTON. Journ. Franklin Institute, 190: 757–815. 1920.

346TH MEETING

The 346th meeting was held at the Cosmos Club at 8 p.m., on Wednesday April 14, 1920.

Informal Communication

Dr. G. R. MANSFIELD showed some enlarged photographs of grains of glauconite from the glauconite-bearing deposits of New Jersey, showing the characteristic forms and microstructure of the grains.

Regular Program

J. S. BROWN: *Fault features of the Salton Basin, California.* (Illustrated.) Salton Basin is in the southeastern corner of California. Its lowest point, now covered by Salton Sea, is 273.5 feet below sea level. The basin is flanked by mountain ranges on the southwest and northeast, but at the southeast it opens toward the Gulf of California, from which it is separated by the delta of Colorado River which is only 50 feet above sea level. The basin floor is a desert plain covered at some places by large sand dunes. At many places the basin is bordered by badlands. The stratigraphy consists essentially of three groups:

(1) Pre-Tertiary crystalline rocks, chiefly Paleozoic and Mesozoic, which underlie the basin and compose the surrounding mountains.

(2) Soft, saliferous sandstone and clay beds of late Tertiary age, usually folded, exposed in the badlands.

(3) Quaternary alluvium, generally undisturbed, forming the basin floor. Salton Basin is generally conceded to be a graben. Numerous faults have been traced to its borders, the most notable being the San Andreas rift, which extends to the northwestern tip of the basin. Topographic and geologic evidence adduced by the writer indicates the existence of a fault 50 miles long between the Tertiary of the badlands and the pre-Tertiary crystalline rocks northeast of Salton Basin. The name Indio fault is suggested. The Indio fault probably is a continuation of the San Andreas rift. Southwest of Salton Basin two systems of faults are distinguished whose intersections are related to the mountain spurs that project into the basin. These faults have disturbed the pre-existing drainage and created a number of isolated mountain-walled valleys. All the faulting observed is of the normal type. The faulting that shaped the basin began before late Tertiary time, but has progressed more or less continuously to the present day, as evidenced by movement along certain faults in recent earthquakes.

A. E. FATH: *Origin of the faults, anticlines, and buried "Granite Ridge" of the northern part of the Mid-Continent oil and gas field.* (Illustrated.)

J. B. MERTIE, JR.: *The Salt Chuck palladium mine near Kasaan, Alaska.*

347TH MEETING

The 347th meeting was held at the Cosmos Club at 8 p.m., on Wednesday, April 28, 1920.

Regular Program.

DAVID G. THOMPSON: *Pleistocene lakes along Mohave River, California.* Mohave River is a typical desert river. It rises in the San Bernardino Mountains in southern California, and flows north to Barstow, thence northeastward along the Los Angeles and Salt Lake Railroad. Except in the mountains its channel is dry for many months at a time. Near the station of Baxter the river emerges from a canyon and spreads over a large alluvial fan, distributary channels carrying the flood water to playas in two separate closed basins, where it disappears by evaporation and absorption.

Lake cliffs and terraces and beach ridges show that a perennial lake once occupied the largest basin which is now occupied by two playas called Silver Lake and Soda Lake. The maximum depth of this ancient lake, which may be called Lake Mohave, was about 40 feet and the area about 75 square miles. A small but distinct channel at the north end shows that it overflowed toward Death Valley.

Evidence of another ancient lake, much smaller than Lake Mohave, was found recently in the second basin, which is now occupied by a playa called Cronise Lake. The name Little Mohave Lake is suggested for this lake.

Buwalda has described Manix Lake that existed in the Pleistocene along Mohave River about 25 miles upstream from Little Mohave Lake. No evidence has been obtained as to the relative ages of these lakes. At present the flood run-off of Mohave River from the San Bernardino Mountains is the only important factor in flooding the playas in the Lake Mohave Basin Under similar conditions in Pleistocene time, if the ancient Mohave River followed approximately its present course, after Manix Lake was formed no great supply of water would have reached the Lake Mohave Basin until Manix Lake overflowed. If, however, Lake Mohave was wholly contemporaneous with Manix Lake, the precipitation in the area directly tributary to the Lake Mohave Basin below Manix Lake must have been considerably greater than it is today. Evidence on the relative age of these lakes will aid in interpreting the climatic conditions under which they existed.

In January, 1916, floods from Mohave River covered Silver Lake playa to a depth of 8 or 10 feet. When the water disappeared 18 months later, many dead fish were found on the playa. These had been carried at least 25 miles from their regular habitat along the river. Fish remains have been reported under similar conditions on the other desert playas. Such occurrences show that fresh-water remains in desert deposits do not necessarily indicate the existence of an ancient perennial fresh-water lake.

The fish belong to two species.—One the common catfish, and the other *Siphateles mohavensis*, which is found only in Mohave River. Other species of the latter genus live in the San Joaquin River, Owens River, Lahontan, and other systems. It is not certain how *Siphateles mohavensis* reached its present habitat, but it is suggested that members of the genus may have migrated from Owens River to Death Valley, through a chain of lakes described by Gale, and thence up the ancient Mohave River, through Lake Mohave. If such a migration took place the same genus ought to be found in Amargosa River which now enters Death Valley.

O. E. Meinzer: *Ground-water problems in the Hawaiian Islands.*

Mr. Meinzer spent February and March, 1920, in the Hawaiian Islands to start a systematic geologic and ground-water survey of the Islands. Work was in progress in 1920 in the Kau district on the Island of Hawaii, by W. O. Clark and L. F. Noble, and in the Honolulu district by H. S. Palmer. The present paper outlined the ground-water problems as seen in this visit of two months.

The rocks of the Hawaiian Islands consist chiefly of small irregular bodies of extrusive lava which is very permeable. This great permeability results in (1) heavy absorption of rain by the rocks, (2) flatness of the water tables, (3) scarcity of springs and streams, (4) large yields of aquifers, and (5) large yields and specific capacities of wells.

The ground water can be divided into two kinds: high-level water and low-level water. The low-level water does not occur much above sea level; the

high-level water may occur hundreds or even thousands of feet above sea level and is held up by definite rock structures such as dikes and interbedded soils and impervious ash.

The high-level water may belong to the main body of ground water or may be a perched body of water not associated with the main body. This water is valuable especially because it does not generally have to be lifted as does the low-level water. The problems of its discovery relate to rock structure and require geologic methods of investigation. The geologic studies should indicate effective but inexpensive methods of prospecting.

The low-level water is in some places non-artesian, but in other places it occurs in artesian basins produced by nearly impervious sedimentary beds overlying the water-bearing lavas. The problems with respect to this water relate chiefly to the quantities available and to contamination by sea water. They require studies of the coasts with respect to emergence and submergence, the consequent development and position of sedimentary deposits, and the effectiveness of these deposits in producing artesian conditions and in protecting the ground water from sea water. They also require quantitative studies of absorption, pumpage, head, and correlative salt content, and studies of the underground leakage of wells and methods for conserving the artesian supply. A valuable contribution to the methods of ground-water investigation developed in the Hawaiian work is the use of current meters for detecting leakage of wells.

Prof. L. C. GRATON spoke on the relation of secondary enrichment to topography and ground water, and especially on the problem of the accumulation of the iron minerals in gossan.

Prof. WM. M. DAVIS was invited by the President to address the Society, and spoke on some reef limestones found in the floors of valleys penetrating the lower slopes of the volcanoes on the Island of Oahu, and their bearing on the diastrophic history of the Hawaiian Islands.

348TH MEETING

The 348th meeting was held at the Cosmos Club at 8 p m , on Wednesday, May 12, 1920.

Regular Program

Stratigraphy of the Bend Series and contiguous formations in north-central Texas.

P. V. ROUNDY. *Micro-paleontology.*

M. I. GOLDMAN: *Lithology.*

The two papers were discussed by Messrs GIRTY, WENTWORTH, HEALD, DAVID WHITE, H. BASSLER, STOSE, ALDEN, LOUGHLIN, and G. R. MANSFIELD.

Mr. GOLDMAN'S paper on *Lithology of the "Bend Series" and contiguous formations of north-central Texas* is the result of the study of a nearly complete series of samples (representing mostly intervals of 10 feet) from 2400 to 4510 feet in the Seaman No. 1 well, Roxana Petroleum Corporation, Palo Pinto County, Texas. In each sample as many types of ingredients as could be recognized were differentiated under the hand lens, and their proportions estimated. Peculiar types and at intervals the common types were made into thin sections, studied under the compound microscope, and the proportion of sand, clay, and lime in each type estimated. Three graphic logs were presented; one showing the estimated proportion of sand, clay, lime, sand flint in each sample, another the usual type of graphic log showing the succession of beds as indicated by the above examinations, the third the usual graphic

presentation of the driller's log. From the first-named log (the "percentage log") it appeared that there are in this well distinct lithologic units characterized by the proportion of the four ingredients differentiated, and that the boundaries between these are usually well defined. From the second log it appeared that these boundaries are usually marked by some distinct bed, some times by a conglomerate or sandstone, but in most cases by a coarsely *glauconitic* sandy bed. In this way it was possible to place the boundary between the Marble Falls (Pennsylvanian) and the Lower Bend (Mississippian) with absolute precision and in conformity with the paleontologic evidence. Boundaries between the Marble Falls, Smithwick, and Milsap were also suggested, though in the absence of paleontologic evidence these are uncertain. Other lithologic units not hitherto distinguished by names were indicated. It was shown that the driller's log gives little if any evidence for the most significant criteria.

In further support of a hypothesis previously offered that *unconformities are marked by glauconitic beds* it was shown that a glauconitic layer occurring at the base of the Lower Bend just above the Ellenberger limestone in outcrops in San Saba County had been traced north through all wells (3) examined in which this contact appeared including the Seaman well more than 100 miles north of the outcrop. It was also indicated that pyrite or other sulfides are associated with glauconite and phosphate at unconformities, and it was suggested that the presence of all three minerals is due to the abundance of organic matter encountered by a transgressing sea.

T. WAYLAND VAUGHAN: *Results of recent studies of the geology of the Northern West Indies.* (Illustrated.) (Read by W. P. WOODRING.)

349TH MEETING

The 349th meeting was held at the Cosmos Club at 8 p.m., on Wednesday, November 10, 1920.

Informal Communication

C. K. WENTWORTH: *A sizing scale for the constituents of sedimentary rocks.* (Presented by M. I. GOLDMAN.)

Regular Program

COURTENAY DE KALB. *The Rio Tinto and other historic mines of Spain.* (Illustrated.)

C. W. GILMORE: *Remarks on the reconstruction of extinct reptiles.* (Illustrated.)

LAURENCE LAFORGE, *Secretary*

350TH MEETING.

The 350th meeting was held in the auditorium of the New National Museum at 8 p.m., on Saturday, November 20, 1920.

Regular Program

WILLIS T. LEE: *An evening "in the air." A popular presentation of the use of aerial photographs in geography.*

Stereopticon views of natural scenery and of objects of geographic interest as seen from an aeroplane were shown, including views of submarine objects and drowned land forms, shown here for the first time. There was also a series of moving pictures taken from hydroplanes, showing scenes along the Potomac, the Pacific fleet passing through the Panama Canal, and scenes along the coast of California. The films were loaned for the evening by the Navy Department.

W. T. THOM, JR., *Secretary.*

351ST MEETING

The 351st meeting was held in the auditorium of the Cosmos Club at 8 p.m., on Monday, December 6, 1920.

Regular Program

O. E. MEINZER. *Recent volcanic events on the Island of Hawaii.* (Illustrated.)

This paper was a concise and graphic presentation of the exceptionally spectacular events in 1919 and 1920 on Kilauea and Mauna Loa—the two active volcanoes of the Hawaiian Islands. It included lantern slides showing one of the lava flows in action, with the two kinds of lava—aa and pahoehoe—being extruded at the same time. The outstanding events of 1919 and 1920, named in chronological order, were (1) long-continued overflow of Halemaumau, the crater of Kilauea; (2) a vigorous lava flow on the flanks of Mauna Loa, nearly 3,000 feet above the level of Halemaumau, this flow reaching the sea, 14 miles from the vent, within 24 hours of the beginning of the eruption; (3) a drop of 600 feet in the lava column in Halemaumau in one night; (4) gradual and quiet opening of fissures radiating from the crater of Kilauea, some of them to a width of 15 feet, (5) gradual rise of lava in some of the fissures and ultimate overflow which developed into a vigorous lava flow with vents about 6 miles from the crater of Kilauea. The specific facts are recorded in the monthly bulletin of the volcano observatory by Prof. T. A. JAGGAR.

The volcanoes of Hawaii have a wide reputation for their gentle habits. When eruptions occur, the inhabitants, instead of fleeing, hastily assemble to see the show. There have, however, been two catastrophes within historic times—an explosive eruption of Kilauea in 1790 which is said to have destroyed an Hawaiian army, and a violent earthquake in 1868 which caused a huge landslide that destroyed many lives. The geological survey of this part of the island begun last year by L. F. NOBLE and the speaker and now being carried out by W. O. CLARK, has, however, revealed numerous beds of volcanic ash and deposits of land-slide material interbedded with lavas at many widely separated horizons, showing that, from the standpoint of geologic time, violent eruptions and huge landslides have not been unusual occurrences.

Baron GERARD DE GEER. *Geochronology and its application to America and to other parts of the Earth.* (Illustrated)

352D MEETING

The 352d meeting was held in the auditorium of the Cosmos Club at 8 p.m, on Wednesday, December 22, 1920.

Regular Program

BAILEY WILLIS: *Evidences of compression on the Pacific Coast.*

After a brief recess the twenty-eighth annual meeting was called to order. The reports of the Secretaries, Treasurer, and Auditing Committee were read and accepted. The following officers were elected for 1921:

President, G. W. STOSE; *Vice-Presidents*, G. F. LOUGHLIN and F. E. WRIGHT; *Treasurer*, G. R. MANSFIELD; *Secretaries*, W. T. THOM, JR., and LAURENCE LAFORGE; *Members-at-large of the Council*, C. N. FENNER, K. C. HEALD, Miss A. I. JONAS, F. J. KATZ, E. T. WHERRY.

LAURENCE LAFORGE, *Secretary*

SCIENTIFIC NOTES AND NEWS

The following educational courses are being offered at the Bureau of Standards this winter: C. A. SKINNER, *Advanced optics;* L. H. ADAMS (Geophysical Laboratory, Carnegie Institution of Washington), *Chemical thermodynamics;* CHESTER SNOW, *Interpretation of data, including the theory of errors and methods for numerical, graphical, and mechanical computation,* L. B. TUCKERMAN, *Differential equations.* The committee in charge consists of L. B. TUCKERMAN, *Chairman;* F. B. SILSBEE, *Secretary;* Miss A. K. BENSON, L. J. BRIGGS, L. V. JUDSON, and C. E. WATERS.

Prof. ERNST COHEN, of the University of Utrecht, Holland, and Prof. J. W. MCBAIN, of the University of Bristol, England, visited the scientific institutions of Washington in September.

Mr. WILLIAM H. GAMBLE, topographer and map engraver with the U. S. Geological Survey, and the oldest employee in the Federal service at the time of his retirement in August, died on September 16, 1921, at the age of eighty-five. Mr. Gamble was born in Philadelphia November 4, 1835. He was engaged in map publishing in Philadelphia until 1895, when he joined the U. S. Geological Survey in Washington.

A department of botany has been organized at George Washington University, in charge of Prof. R. F. GRIGGS, formerly of Ohio State University and recently director of the Katmai Expeditions of the National Geographic Society.

Mr. RALPH C. HOLDER has resigned as junior chemist in the food research laboratory, Bureau of Chemistry, to take charge of the chemical laboratory of the Collis Products Company of St. Paul, Minnesota.

Dr. WALTER PROCTOR JENNEY, mining engineer, died at his home at 1417 Park Road on September 16, 1921, in his seventy-third year. Dr. Jenney was born at Fairhaven, Massachusetts, January 11, 1849. He was mining engineer for several railroad and mining companies during the period of development of the mineral resources of the West, and was with the U. S. Geological Survey in the years 1889–1892. In 1909 he became interested in the investigation of ship forms for the Navy Department and was in that work through the War period. Since 1919 he had been engaged in research work for the Department of Agriculture.

Mr. HUGH MILLER, recently captain in the U. S. Army and instructor in the engineers' school at Camp Humphreys, and formerly a member of the engineering faculties of Clarkson School of Technology at Potsdam, New York, and Rice Institute of Houston, Texas, has been appointed professor of civil engineering at George Washington University.

Mr. SAMUEL STOCKTON VOORHEES, engineer and chemist at the Bureau of Standards, died at Portland, Maine, on September 23, 1921, in his fifty-fifth year. Mr. Voorhees was born at Springfield, Ohio, January 15, 1867. During the first fifteen years of his professional work he was chemist or engineer of tests for several of the eastern railroad companies. From 1901 to 1908 he was with the supervising Architect's Office of the U. S. Treasury, and then went into chemical work at the U. S. Geological Survey. Since 1910 he had been in the chemical division of the Bureau of Standards, in charge of the chemical work on structural materials. He was a member of the ACADEMY, a past president of the Chemical Society, and a member of the Biological Society.

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INORGANIC CHEMISTRY.—*The crystal structures of the alkali halides.*[1] I. RALPH W. G. WYCKOFF, Geophysical Laboratory, Carnegie Institution of Washington. (Communicated by Arthur L. Day.)

Introduction.—A knowledge of the crystal structures of a large number of chemical compounds will furnish information concerning the nature of the atoms themselves and of their manner of combination one with another. Though the structures of most complicated compounds, especially those having a symmetry that is other than cubic or rhombohedral, cannot yet be obtained with certainty and exactness because of the absence of precise knowledge concerning the laws of scattering, there are many simple substances in which the arrangement of their constituent atoms can be determined with all of the assurance of correctness with which the structure of any crystal can now be obtained Of these substances the simplest, aside from the elements themselves, are compounds of the type RX, where R is an electropositive atom and X is a more electronegative (electron-seeking) atom of equal valence. This paper furnishes an account of the study of the crystal structures of one class of the compounds RX, the alkali halides.

The possibility, which seems to arise from a consideration of the structures of simple crystals, of assigning definite sizes to the various atoms and building up crystals by the close packing of these atoms has already been given especial attention.[2] Most of the data upon which this work was based were obtained by assuming a particular arrangement of the atoms in the crystals and by calculating the dimensions of the unit cells with the aid of the published values of the densities of the crystals. In view of the unreliable character of these density determinations and because of the inability to choose between the different structures that are possible for these simple crystals,

[1] Received October 10, 1921

[2] W. L. BRAGG Phil Mag (6) 40: 169. 1920.

it is evident that a satisfactory decision concerning the constancy of atomic dimensions can only be made after more direct information is available through studies of the crystal structures of these compounds.

A detailed discussion of the bearing of these results upon the problem of the shapes and sizes of atoms will be deferred until data upon other simple structures have been given.

The method of determination.—The structures of these alkali halides were obtained from a study of their powder photographs.[3] A discussion of all of the simple ways of arranging the atoms of the compound RX that are geometrically possible, together with the manner of calculating in a qualitative fashion the nature of the diffraction effects to be expected from each of these possible arrangements, has been given elsewhere.[4] With the following exception this same method of calculation is pursued in these determinations.

A closer accord of the "normal decline" of intensity of "reflection" with the spacing of the reflecting planes as observed by spectrometer measurements upon sodium chloride and other simple crystals[5] is obtained by assuming that the intensity is proportional to the 2.35 power of the spacing instead of the simple square The calculated intensities thus obtained by writing

$$f(d/n) = (d/n)^{2.35}$$

give, as the following results will show, a surprisingly close qualitative agreement with the intensities of the corresponding diffraction effects as estimated from the photographs.

Since a study of four or five of the most intense lines in the spectrum was in all cases sufficient to decide between the different possible structures, the accompanying tables will be limited to recording the data from them only In many cases, however, the number of observed lines was as great as ten or fifteen Many lines could not be observed in the spectra obtained with rubidium salts and from bromides because of the large amount of secondary radiation emitted by rubidium and bromine.[6] The dimensions of the unit cell were obtained in each

[3] A W HULL Phys. Rev. (2) 10: 661. 1917, P DEBYE and P SCHERRER Phys. Zeitschr 17: 277 1916.

[4] RALPH W G WYCKOFF and EUGEN POSNJAK. *The crystal structures of the cuprous halides.* Journ Amer Chem. Soc. (in press)

[5] W H. BRAGG and W. L. BRAGG. *X-rays and crystal structure* (London, 1918).

[6] Trouble from this secondary radiation could have been eliminated for the most part by the use of a second filtering screen placed next to the photographic plate. Such a film was not, however, available at the time these experiments were carried out.

case by averaging the values calculated from these first three or four lines.

Unless the true symmetry of these crystals is either tetrahedral or tetratohedral cubic,—and there is no evidence for either of these two kinds of symmetry,—the number of arrangements having four molecules within the unit cell is limited to two: the "sodium chloride" arrangement or the "zinc sulfide" arrangement.

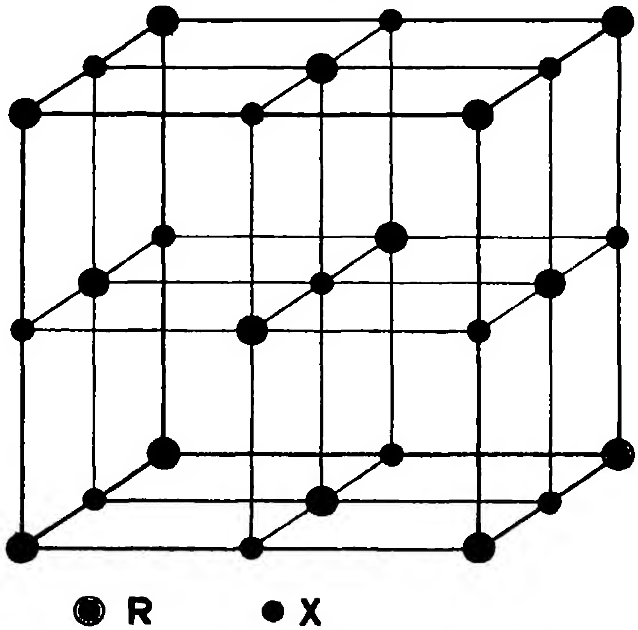

Fig. 1. The unit cell of the sodium chloride grouping.

Sodium chloride

The spectrograph used in all of these experiments was standardized using sodium chloride, the length of the unit cell[7] of which was taken to be 5.628×10^{-8} cm.

Sodium bromide

The positions of the spectrum lines together with the previously determined value of the density clearly show four molecules to be associated with the unit cell.

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
111(1)	4	20,120	47,300
100(2)	6	40,000	10,850
110(2)	6	35,300	35,300

Calculated density = 3.20

Spacing: $d_{100} = 5.95 \pm 0.01$ A. U.

Structure: NaCl grouping (Fig. 1).

[7] W. Duane. Bull. Nat. Research Council 1: 383. 1920.

Sodium iodide

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
111(1)	9	62,200	103,000
100(2)	10	77,000	33,300
110(2)	8	68,000	68,000
113(1)	5	40,400	67,000
111(2)	2	28,100	12,100

Calculated density = 3 62
Spacing d_{100} = 6 47 ± 0 01 A U
Structure NaCl grouping

Potassium chloride

It has been shown that potassium chloride has the same structure as sodium chloride.[8] The length of the side of the unit cell is given as 6.26 A U

Potassium bromide

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
111(1)	0 5	9,030	55,900
100(2)	10	55,000	4,830
110(2)	10	48,500	48,500
120(2)	3	32,900	2,890
112(2)	3	26,800	26,800

Calculated density = 2 73
Spacing d_{100} = 6 59 ± 0 02 A U
Structure NaCl grouping

Potassium iodide

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
111(1)	8	40,700	111,800
100(2)	10	97,700	21,800
110(2)	9	86,700	86,700
113(1)	4	26,400	72,500
111(2)	4	35,600	7,940

Calculated density = 3 03
Spacing. d_{100} = 7.11 ± 0 02 A U
Structure NaCl grouping

Rubidium chloride

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
100(2)	6	54,800	7,530
110(2)	6	48,400	48,400
111(2)	2	19,950	2,740
120(2)	2	32,900	4,520

Calculated density = 2 76.
Spacing: d_{100} = 6.60 ± 0 02 A U.
Structure: NaCl grouping.

[8] W H Bragg and W L Bragg. *Op cit*

Rubidium bromide

The structure of this crystal has already been determined[9] as identical with that of sodium chloride; $d_{100}=6.93$ A U.

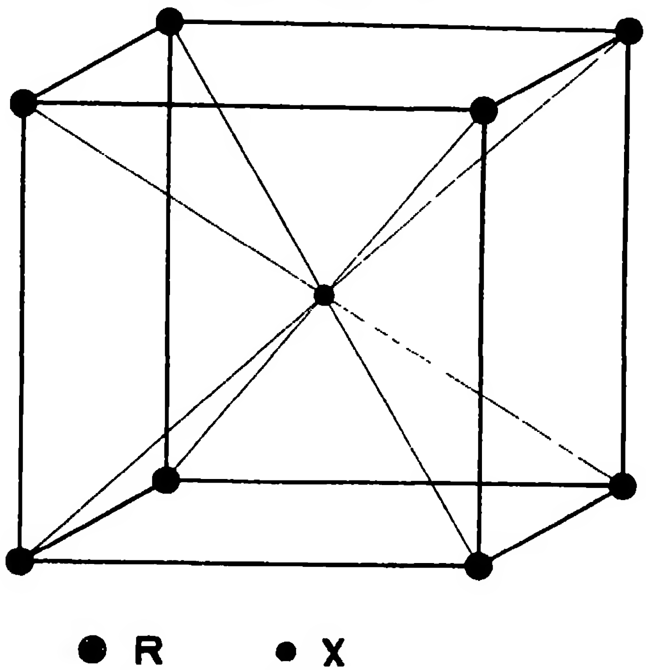

Fig 2 The unit cell of the body-centered grouping

Rubidium iodide

hkl	Estimated intensity	Calculated intensity NaCl grouping	Calculated intensity ZnS grouping
100(2)	6	153,000	4,830
110(2)	6	135,200	135,200
100(4)	1	30,000	30,000
120(2)	2	91,800	2,890

Calculated density = 3 49
Spacing $d_{100}=7\ 36 \pm 0\ 02$ A U
Structure NaCl grouping

Caesium chloride

Caesium chloride has been shown[10] to be body-centered, $d_{100}=4.12$ A. U.

Caesium bromide

Calculations based upon the positions of the lines in the photographs and the previously determined density show that but one molecule

[9] W P DAVEY Phys Rev (2) 18: 103 1921.

[10] W P DAVEY and F. G WICK Phys Rev (2) 17: 403 1921

is to be associated with the unit cell. The arrangement is thus a body-centered one (unless a complicated structure having at least eight chemical molecules in the unit cube is to be assumed).[11]

hkl	Estimated intensity	Calculated intensity for body-centered grouping
110(1)	10	43,000
100(2)	2	9,530
112(1)	7	23,700
110(2)	2	8,420
130(1)	3	12,800

Calculated density = 4 39

Spacing d_{100} = 4 30 ± 0 01 A U

Structure Body-centered grouping (Fig 2)

Caesium iodide

One molecule in unit cell.

hkl	Estimated intensity	Calculated intensity for body-centered grouping
110(1)	10	61,600
100(2)	2	13,710
112(1)	8	34,100
110(2)	1	12,100
130(1)	4	18,450

Calculated density = 4 54

Spacing d_{100} = 4 55 ± 0 015 A U

Structure Body-centered grouping (Fig 2)

Results of the determinations of the crystal structures of other alkali halides will be given in a subsequent number of this JOURNAL.

ORNITHOLOGY.—*Three new birds of the family* Tinamidae *from South America*[1] ALEXANDER WETMORE, Biological Survey.

Study of tinamous in the United States National Museum of the genera *Rhynchotus*, *Nothura*, and *Calopezus*, has led to the identification of three forms that have been unrecognized hitherto. They may be known from the following detailed descriptions.

Rhynchotus arcanus, sp nov

Characters—Similar to *Rhynchotus rufescens* (Temminck); outer webs of three outermost primaries, alula, and both webs of greater wing-coverts barred narrowly with blackish; more heavily barred with black above; bill slightly more slender at base.

Description.—Type, Cat. No. 21061, U. S. Nat. Mus., adult, sex not known, collected at Paraná, Entre Ríos, Argentina, March, 1860, by Capt. T. J. Page. Crown black, lateral feathers and those on fore part of crown margined narrowly with chamois, forming an indistinct median stripe on anterior third of crown, median feathers of hinder portion of crown margined with cinnamon; sides of head dull cream-buff, lighter on lores and below eyes, changing to chamois behind eyes; streak from eye through ear, ear coverts, and a narrow

[11] RALPH W G WYCKOFF and EUGEN POSNJAK, *op. cit*

[1] Received October 3, 1921.

rictal streak dull black; hindneck tawny-olive, paler on sides of neck, base of hindneck becoming pale Saccardo's umber, barred with black; back, tertials, inner secondaries and rump, Saccardo's umber, barred heavily with black, the black bars margined distally with pinkish buff, tips of feathers pinkish buff; outer secondaries, wing-coverts, tail, and upper tail-coverts similar but with black markings greatly restricted so that they are less in area than the lighter colors, outer greater coverts with Saccardo's umber replaced by orange-cinnamon; alula and primaries hazel, outer webs of alula and of three outermost primaries barred narrowly with black, dark markings faintly indicated on outer webs of other primaries; tips of primaries becoming mouse gray, outer webs paling to cinnamon; secondaries hazel, barred across tips and on outer webs with black; chin and throat whitish (apparently discolored by stain); foreneck and upper breast tawny-olive, feathers of neck in front and on sides with dark streaks extending to ends of shafts, nearly concealed except on foreneck, broader basally and narrowed distally; rest of underparts drab, feathers of breast and lower sides of neck with indistinct markings of chamois; sides, flanks and under tail-coverts barred strongly with black, the black bars margined distally with pale olive-buff; abdomen and tibiae barred narrowly with black; under wing-coverts hazel, anterior margin of shoulder drab barred with black, with occasional lighter bars of pinkish buff. Maxilla dull black, becoming brownish at margins; mandible and maxilla below nostril honey yellow, darker at tip of mandible; tarsus and toes mikado brown, more or less discolored from grease (in dried skin).

Measurements of type.—Wing 188.5 mm., tail (from base of coccyx to tip of longest feather) 63 mm., exposed culmen 42 mm., tarsus 61.3 mm.

Range.—Known from Paraná in the Province of Entre Ríos, Argentina.

Remarks.—The bird described above as *Rhynchotus arcanus* is so distinct from any of the known forms of the rufous-winged tinamou, *R. rufescens* (Temminck), as to necessitate recognition as a full species. For some time I was under the impression that the strongly barred wing feathers in this individual might possibly represent the juvenal plumage of *rufescens*, but examination of a three-quarters-grown *Rhyncholus rufescens alleni* Chubb from Matto Grosso, borrowed from the American Museum of Natural History through the kindness of Dr. F. M. Chapman, shows that the immature bird agrees with the adult in plain, uniform flight feathers without prominent markings. The presence of dark lines on the foreneck and of squamate paler markings on the breast in *arcanus* suggest the condition found in *R. maculicollis* G. R. Gray, a species known from present published records from Bolivia (the type locality) and the Province of Tucumán, Argentina. It is possible that the bird from Paraná eventually may prove to be a pale eastern form of *maculicollis*.

Nothura maculosa savannarum, subsp. nov.

Characters.—Similar to *Nothura maculosa nigroguttata* Salvadori but less mottled above, with black markings on dorsal surface much more extensive, covering the major part of the feathers of back and rump; hindneck paler, with finer streaks; markings on breast darker, confined to small heart-shaped spots or elongate marks toward tips of feathers; lateral bars on underparts bolder, not extending so far inward toward the median line.

Description.—Type, U. S. Nat. Mus., Cat. No. 283655 (Biological Survey Collection), adult female, collected near San Vicente, Department of Rocha, Uruguay, January 27, 1921, by Alexander Wetmore (collector's no. 5827). Crown black, the feathers tipped irregularly with cinnamon-buff, with poorly defined median stripe of cartridge buff and chamois; broad superciliary stripe and lores dull cream-buff, with slight admixture of whitish, the feathers bordering the crown lightly streaked with dull black; sides of head between cream-buff and chamois; auricular region dull black, feathers behind rictus streaked with black forming a distinct stripe, hindneck cream-buff with an admixture of cartridge buff, with median streak of black that becomes broader and heavier toward the back; back, rump and tertials black, the feathers bordered by lighter margins shading from chamois at the base through cream-buff to cartridge buff near the tip; each feather faintly and irregularly barred with dark chamois, these vermiculations greatly reduced in extent; upper tail-coverts barred and margined broadly with chamois; wing-coverts between chamois and honey yellow, tipped with cartridge buff and barred broadly with black; primaries and secondaries fuscous (paler through wear and fading at tips); outer primaries with outer webs barred regularly with cinnamon-buff at base, the light bars becoming white toward tip of feathers; both webs of inner primaries and secondaries barred broadly with cinnamon-buff; throat and lower margin of cheeks white; breast, abdomen, lower tail-coverts, flanks, and under wing-coverts between chamois and honey yellow, the tips of the feathers on breast and abdomen washed with olive-buff; upper breast with small heart-shaped spots of dull black, these becoming narrow and more linear on fore neck, and broader and heavier laterally, sides and flanks barred heavily with dull black; lower breast and abdomen immaculate, under tail-coverts marked indistinctly with fuscous; outer side of leg with vermiculations of dull black; extreme outer under wing-coverts barred with dull black. Maxilla slightly darker than natal brown, at base becoming benzo brown, mandible very dull pinkish buff, duller toward tip; tarsus and toes between fawn color and army brown (in dried skin)

Measurements of type.—Wing 139.5 mm., tail[2] 43 mm., exposed culmen 18 mm., tarsus 37.5 mm., middle toe with claw 35 mm.

Geographic range.—Eastern Uruguay (known from Department of Rocha).

Remarks.—This distinct form differs from typical *Nothura maculosa maculosa* (Temminck) from Paraguay in much paler, less brownish coloration, and in the characters assigned in the diagnosis as distinguishing *savannarum* from *N. m. nigroguttata.* It differs so markedly from other described forms of spotted tinamous that it requires no further comparison with any save *Nothura m. minor* (Spix) described from Tejuco (now called Diamantina), Minas Geraes, Brazil. This form, according to Hellmayr,[3] is related to *N. m. maculosa* but is smaller (wing 110 to 116 mm.), more chestnut above, and paler with darker more restricted spottings and streakings below. No specimens of this bird are available at present. In color of underparts *minor* is similar apparently to *savannarum*, but it differs in its smaller size and its much more rufescent color above. The form described here from eastern Uruguay is supposed to range through Rio Grande do Sul, Brazil.

[2] Measurement of the tail is taken from coccyx to tip of longest filaments of the mixed rectrices and tail coverts.

[3] Abh. Kön. Bayer. Akad Wiss II Kl. 22: 707. 1906.

Calopezus elegans albidus, subsp. nov

Characters.—Similar to *Calopezus elegans morenoi* Chubb but much paler white spots and broken bars of upper surface large, the light markings of the dorsal surface more extensive than the darker ones; feathers of lower hindneck marked extensively with dull ivory yellow; light markings on under surface more extensive.

Description.—Type, U. S. Nat Mus., Cat. No. 71061, adult (sex not indicated), San Juan, Argentina. Feathers of crown and nape light drab, each feather with a narrow median streak of dull black, loral region dull pinkish buff, each feather streaked with dull black; superciliary streak paler than, cartridge buff; a narrow line extending beneath eye from base of nasal groove dull pinkish buff, becoming whiter as it expands on the cheeks where it is lined with dull black; malar streak dull black, the feathers bordered with whitish; sides of head dull black, the feathers bordered narrowly with light drab; elongate crest, composed of slender feathers slightly recurved at tip, dull black, bordered narrowly toward base with light drab; hindneck between smoke gray and light grayish olive, slightly streaked with black, feathers of lower neck and upper back dull ivory-yellow, with shaft streak and five or more narrow bars of fuscous-black, the dark bars more or less broken and interrupted; feathers of back, inner wing-coverts and tertials mottled and barred with mixed ivory-yellow and fuscous-black, with an admixture of drab replacing part of the lighter markings; rump and upper tail-coverts similar to back but with bars of light and dark heavier and more distinct, the light markings varying from ivory-yellow to nearly white; outer wing-coverts barred irregularly but heavily with ivory-yellow and fuscous-black, the light markings in places almost white; primaries and secondaries dull fuscous-black; outer webs of primaries barred narrowly with ivory-yellow, an indefinite broken bar of the same color on inner web, secondaries crossed with irregular bars of ivory-yellow; rectrices barred narrowly with fuscous-black and ivory-yellow; throat dull white; foreneck and upper breast dull ivory-yellow, each feather with shaft streak and several faint wavy vermiculations of fuscous-black; breast, abdomen, sides, flanks and under tail-coverts ivory-yellow barred broadly with fuscous-black; abdomen ivory yellow, the abdomen tending to become immaculate toward center; thighs pale ivory-yellow; under wing-coverts and axillars dull white, barred with fuscous-black.

Measurements of type.—Wing 211 mm., tail 97.5 mm., tarsus 40.6 mm., culmen 25 mm.

Range.—Province of San Juan, Argentina.

Remarks.—The pale coloration of *Calopezus e. albidus* distinguishes it at a glance from other subspecies of the crested tinamou. It is as distinct from *C. e. formosus* Lillo of eastern Tucumán and northwestern Santiago del Estero, as from *C. e. morenoi* which ranges north into the Province of Mendoza. The peculiarities of this pale form were described to me by sportsmen who were familiar with it in the field, and who distinguished it from the darker subspecies of other regions. The type, an old specimen in the U. S. National Museum, has no definite locality assigned on the label other than the Province of San Juan, but it seems probable that *albidus* ranges through the plains of eastern San Juan.

AGRICULTURAL CHEMISTRY.—*The effect of alum on silicate colloids.*[1] C. S. SCOFIELD, Bureau of Plant Industry.

On the irrigated lands of the western United States there are numerous instances where the soil contains soluble silicates, chiefly combined with sodium Where the stronger acids, the sulfates and the chlorides, are removed by the leaching action of irrigation these colloidal silicates cause serious trouble by checking the free movement of water through the soil and by cementing the soil particles into a solid mass when the water is evaporated.

The complete reclamation of salty irrigated land is often difficult or impossible because of the presence of these colloidal silicates, which cannot readily be leached from the soil The occurrence of sodium silicate as an important component of the salt complex of arid soils has not been generally recognized, probably because it does not readily leach out of the soil It is also often confused with sodium carbonate or "black alkali" since both salts give an alkaline reaction with phenolphthalein. It now seems probable that the well-known puddling effect in soils usually ascribed to sodium carbonate is to be explained as due to sodium silicate.

In attempting to improve the physical condition of certain irrigated soils that are relatively impermeable to water and that become very hard on drying, it has been found that aluminum sulfate is very effective. This salt is readily soluble and in solution reacts directly with sodium silicate forming an insoluble aluminum silicate and leaving in the soil solution the resulting sodium sulfate which may be removed easily by leaching

The results of such laboratory and field experiments as have been made indicate that aluminum sulfate may be used freely on alkaline irrigated land without injury to succeeding crops. In fact an examination of the leachings from soils to which liberal applications of aluminum sulfate have been made shows that practically all the aluminum is precipitated in the soil and that corresponding quantities of sodium, calcium, and magnesium are released into the soil solution combined with the sulfate radicle.

In view of the possibility that aluminum sulfate may come to be used extensively in the reclamation of alkali lands under irrigation it is fortunate to find that there are numerous deposits of alum in the western United States. Some of these deposits appear to contain alum in soluble form while in other cases it occurs as alunite which

[1] Received October 10, 1921

may be converted into the soluble form by grinding and heating with sulfuric acid, a commodity readily available at western smelters

It remains to be determined what rate of application of aluminum sulfate will be required for different alkali soils. Marked improvement in permeability to water and in physical condition on subsequent drying have been noted from applications at the rate of one ton per acre while much heavier applications have not shown any deleterious effect on subsequent crop growth. It is believed that the discovery of the beneficial effect of alum on alkaline irrigated land opens a wide field of investigation in this perplexing subject.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors The abstracts should conform in length and general style to those appearing in this issue

PHYSICS.—*The present status of the constants and verification of the laws of thermal radiation of a uniformly heated enclosure.* W W COBLENTZ Bur. Standards Sci. Papers **17**: 7–48 (No. **406.**) 1921

An examination is made of the instruments, methods, and experimental data pertaining to various determinations of the constant, σ, of total radiation and the constant, c, of spectral radiation of a black body. After making obvious corrections for reflection from the receiver and for atmospheric absorption, the determinations of various experimenters are in close agreement, giving a value of $\sigma = 5.72 \times 10^{-8}$ ergs, and $c = 14320$ micron degrees. W. W. C.

SPECTROSCOPY.—*Wave-length measurements in arc spectra photographed in the yellow, red and infra-red.* F. M. WALTERS, JR Bur Standards Sci. Papers **17**: 161–177. (No. **411.**) 1921

For several years the Bureau of Standards has been conducting grating measurements in red and infra-red arc spectra by the aid of specially sensitized photographic plates to improve the data and to find some element which would furnish lines suitable for wave-length standards in this region. To the measurements on 25 elements already made, the following are here added: Silver, Aluminum, Gold, Bismuth, Cadmium, Mercury, Lead, Antimony, Tin, Zinc. The wave-length measurements are in the international system and are given to 0 01 A.

The elements were brought to luminosity by inserting a sample in copper or graphite electrodes between which the arc was maintained. The grating used had 297 lines per mm. and a 640 cm. radius. The spectra were photographed in the first order on plates sensitized with pinacyanol or dicyanin. The comparison spectrum was iron in the first, second, or third order, and in the reductions the wave-lengths established by interference methods were used. F. M. W.

PHYSICS.—*The use of the Ulbricht sphere in the measurement of reflection and transmission factors.* ENOCH KARRER. Bur. Standards Sci Papers **17**: 203–225. (No. **415.**) 1921.

A brief historical survey is given of the methods and instruments used in measuring the reflection factor of surfaces. The various ways in which the

sphere has been used up to recent years are briefly described. The recent applications of the sphere in a manner that affords the absolute determination of the reflection factor are also described, and several new ways of using the sphere are pointed out. One of the new ways consists in a combination of the sphere with the Martens polarization photometer, which enables a direct comparison to be made between the brightness of the sphere wall and the brightness of the test surface which closes an aperture in the sphere. The sphere wall is illuminated by directing a narrow beam of light through an aperture on to a spot of the sphere walls adjacent to the aperture that is closed by the sample. The sample is illuminated by the sphere wall, but is screened from the direct light from the illuminated spot. The ratio of brightness which is obtained by means of the Martens photometer is exactly the reflection factor of the test surface.

Thus the reflection factor is determined by one observation without further calculation, and without the use of a standard reflecting surface This method may be modified so that the transmission factor may likewise be determined absolutely. The theory of the hollow sphere (commonly referred to in technical literature as the Ulbricht sphere) is given to show how this reflectometer in theory and practice conforms with it. The use of the sphere in some such manner as this is a step toward standardization. E. K.

METALLOGRAPHY.—*The structure and related properties of metals*. Bur. Standards Circular **113**. 1921.

This circular is a comprehensive discussion of the phase of metallography indicated by the title With but very few exceptions, the numerous illustrative examples which have been used throughout the text as types have been taken from the results of examinations of metallographic specimens submitted to the Bureau for examination and test.

In the discussion of the methods for revealing the structure of metals, the various reagents used in the macroscopic study of metals are described particularly as related to the purpose for which they are used, that is, for revealing chemical unhomogeneity, crystalline heterogeneity, physical unsoundness and mechanical nonuniformity. The principles underlying the action of etching reagents are discussed, and a list of suitable reagents for revealing the microstructure of the common industrial metals and alloys given.

Chief among the conditions which affect the structure of an alloy is chemical composition, and for any particular system of alloys this is graphically summarized in the constitutional or structural diagram The structure is also profoundly affected by temperature; for example, upon heating, an alloy tends to assume a condition of physico-chemical equilibrium by diffusion, etc., so that after heating, the structure may be profoundly different from the initial state Grain growth and phase changes upon heating are also of importance, particularly the latter, as it is to this property that the value of heat treatment as a means of obtaining wide variations in the physical properties of steel and other alloys is due The mechanical deformation which constitutes the "working" of a metal also has a decided effect upon its structure.

GEODESY.—*Relation between plane rectangular coordinates and geographic positions*. WALTER F. REYNOLDS. U S. Coast and Geodetic Survey, Spec. Publ 71 (Serial 159). Pp. 89, figs. 2. 1921.

Control surveys covering large areas are made and computed by the use of geographic coordinates (latitudes and longitudes) because of the curvature of the earth. For this reason results of triangulation in publications of the

U. S. Coast and Geodetic Survey, the U. S Geological Survey, and the U. S. Corps of Engineers are always given in geographic coordinates When surveys are made over small areas such as are occupied by cities and small counties, the use of plane coordinates is more convenient and the computations are simplified.

The tables in this publication enable the county or city surveyor who wishes to use the stations given in the above-mentioned government publications for the control of his surveys, to convert quickly the geographic coordinates given there into plane coordinates without the use of difficult formulas. The development of the formulas used in the computation of the tables is given in an appendix at the end of the book. W F. R.

INORGANIC CHEMISTRY —*The crystal structure of magnesium oxide.* RALPH W G. WYCKOFF Amer Journ Sci. 1: 138–151 1921

An attempt has been made, using Laue photographs and X-ray spectrum measurements, to get a *unique* solution for the crystal structure of magnesium oxide. If it possesses holohedral symmetry, then the only simple structure which is possible is the "sodium chloride arrangement." Certain cases of grouping showing tetratohedral symmetry, and two more complicated holohedral arrangements, each with thirty-two molecules associated with the unit, are in agreement with the existing experiments. These other possibilities, however, differ but slightly from the "sodium chloride arrangement," and cannot be positively treated by the experimental facilities now available. R W G. W.

MINERALOGY.—*Note on augite from Vesuvius and Etna* HENRY S WASHINGTON and H. E MERWIN. Amer. Journ Sci 1: 20–30. 1921.

The paper includes a description and analysis of crystals of augite collected at the bottom of the crater of Vesuvius in 1914 The chemical composition of the crystals is almost identical with that of pyroxenites of Monte Somma, described by Lacroix. The relative merits of the gravitative-adjustment and fractional-crystallization theories of certain forms of differentiation are discussed.

Crystals of augite from Monti Rossi, from the eruption of Etna in 1669 are also described, with a new analysis and optical determinations. No good analyses of the augites of either Vesuvius or Etna are to be found in the literature. Spallanzani (circa 1790) was the first to determine the relative melting points of the feldspars and augite, and to measure their relative magnetic susceptibility; he is therefore to be regarded as the first experimental geophysicist. The paper also gives a comparison of the chemical compositions of various Italian augites with the lavas that contain them H. S. W

GEOLOGY.—*The Divide silver district, Nevada.* ADOLPH KNOPF U. S Geol. Survey Bull. 715-K. Pp. 24 (147–170) 1921.

The Divide district, one of Nevada's newest silver camps, centers at Gold Mountain, 5 miles south of Tonopah. The discovery of silver ore that started the great activity at this camp was made late in 1917, wholly by chance A crosscut was being driven to cut a small gold vein that had been worked higher on the slope of Gold Mountain intermittently since 1902, and before it had been driven far enough to cut the gold vein it quite unexpectedly intersected a rich silver-bearing lode. Further exploration indicated that a large and valuable ore body had thus accidentally been discovered.

The prevailing rock in the Divide district is the Fraction rhyolite breccia. This is intruded by several stocks of the Oddie rhyolite and by a large mass

of andesite. Later than all of these is a series of latite lava flows, which cap the highest peaks of the district.

The ore bodies are zones of fracturing and shearing in the Fraction rhyolite breccia; strictly speaking they are lodes, not veins. The chief silver-bearing mineral is cerargyrite (horn silver), which is commonly concentrated in rich masses along irregular seams of sericite that traverse the lodes. The primary metalliferous material is leanly mineralized rhyolite breccia carrying a small amount of finely disseminated pyrite and threaded by thin veinlets of exceedingly fine-grained quartz. What the primary silver-bearing mineral is has not been determined. The scarcity of quartz or of silicification is a noteworthy feature of the ores of the Divide district, especially in contrast with the high silica content of the ores in the adjoining district of Tonopah. The silver in the lean primary material of the lodes was concentrated by downward enrichment as soft "sooty" argentite, and subsequently most of this supergene argentite was converted to horn silver. A. K.

GEOLOGY and HYDROLOGY.—*Exploratory drilling for water and use of ground water for irrigation in Steptoe Valley, Nevada.* W. O. CLARK and C. W. RIDDELL, with an introduction by O. E. MEINZER. U. S. Geol. Survey Water-Supply Paper 467. Pp. 70, pls. 6, figs 6. 1920.

Steptoe Valley, in east-central Nevada, is about 95 miles long and 900 square miles in area. It lies in a structural trough between northward-trending mountain ranges and contains thick deposits of alluvium with underlying lake beds. Ancient shore features show that the valley once contained a lake about 30 miles long which discharged northward into Gosiute Valley. The valley is too arid for agriculture without irrigation, and the supply of surface water is meager.

The paper gives the results of test drilling that was done by the Geological Survey, as authorized by Congress, for the purpose of finding water for irrigation. The test wells demonstrate that beneath the desert surface are stored supplies of water adequate in quality and quantity for irrigation. The paper also comprises a systematic description of the hydrology of the valley with special reference to the interpretation of the results obtained in drilling. It includes numerous measurements of stream flow and absorption, on the basis of which it is estimated that the perennial streams contribute about 20,000 acre-feet a year to the ground-water supply and that the total annual ground-water supply is probably not less than 50,000 acre-feet. Certain plant species were found to feed habitually on the water in the zone of saturation, and different species were found to indicate different depths to the water table. The detailed map shows the zones of the principal water-indicating plants, the areas of active and intermittent ground-water discharge, and the estimated depths to the water table. It shows that water is being discharged from the zone of saturation, through soil and plants, in an area of about 115,000 acres. The paper also describes a number of large springs, some of which are thermal. It includes a map of Nevada showing 38 Pleistocene lake beds thus far discovered lying wholly or partly in the State, four of which were mapped in the present investigation. O. E. M.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

BOARD OF MANAGERS

At the 248th meeting of the Board, on February 28, 1921, the Editors of the JOURNAL were authorized to classify the ACADEMY'S excess stock of separates from the *Proceedings* (1898–1911) and to publish lists of these papers on the back cover of the JOURNAL, offering the papers for sale for a limited period at prices from one third to one fifth the regular price. (Publication of the lists was begun on March 4.) Messrs. C. L. ALSBERG, F. V. COVILLE, H. S. GRAVES, A. D. HOPKINS, and E. W. NELSON were appointed a committee to represent the ACADEMY at the Lubin Memorial Meeting. At the suggestion of the Botanical Society, the President appointed a committee to investigate the facts regarding the sending of scientific literature to Russian scientists, the committee consisting of A. S. HITCHCOCK, VERNON KELLOGG, and RAPHAEL ZON.

The 249th meeting, on March 14, and the 250th, on March 28, were devoted to elections of members and routine business. The committee to consider transmission of literature to Russia reported on the existing situation, but not enough information was available to warrant the Board in adopting any definite proposals for action. At the 251st meeting, on May 2, the Board voted to endorse the Mt. Hamilton project for a National Botanic Garden, and Messrs. H. S. GRAVES, F. V. COVILLE, and T WAYLAND VAUGHAN were appointed a committee to cooperate with the Washington Society of the Fine Arts and any other interested organizations in forwarding the project. Mr. A. S. HITCHCOCK resigned as Vice-President from the Botanical Society on account of absence from the United States, and Mr. MICHAEL SHAPOVALOV was elected to succeed him.

At the 252d meeting, on May 23, the committee on distribution of the *Proceedings* reported that sets in libraries which had been on the mailing-list had been completed in about 90 cases, and that complete sets were being offered to a selected list of libraries which had not formerly received the publication.

The following Committee on Meetings for the season 1921–1922 was announced at the 253d meeting, on August 1 W. J. HUMPHREYS, *Chairman*, W. D. BIGELOW, O. C. MERRILL, A. C. SPENCER, and W. T. SWINGLE. The preliminary report of the committee on a list of popular books in science for the Public Library was considered in detail, and approved for publication in the JOURNAL as a tentative list subject to revision.[1] Election of members and routine business were taken up at the 254th meeting, on September 26.

The following persons have become members of the ACADEMY since the last report in the JOURNAL (March 19, 1921, p. 130)

DR. SUMNER CUSHING BROOKS, Hygienic Laboratory, U. S Public Health Service, Washington, D. C.

[1] See This JOURNAL 11: 353–366. September 19, 1921

Dr. FREDERICK GARDNER COTTRELL, National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

Prof. ROBERT FISKE GRIGGS, National Geographic Society and George Washington University, Washington, D. C.

Prof. MAYO D. HERSEY, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Dr. EARL S. JOHNSTON, Maryland Agricultural Experiment Station, College Park, Maryland.

Dr. E. LESTER JONES, U. S. Coast and Geodetic Survey, Washington, D. C.

Dr. ROBERT HAMILTON LOMBARD, Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C.

Dr. HENRY C. MACATEE, 1478 Harvard Street, Washington, D. C.

Dr. RICHARD BISHOP MOORE, U. S. Bureau of Mines, Washington, D. C.

Dr. ROBERT W. SAYLES, Geological Museum, Harvard University. Cambridge, Massachusetts.

Assistant Surgeon General J. W. SCHERESCHEWSKY, U. S Public Health Service, Washington, D. C.

Dr. MICHAEL SHAPOVALOV, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Dr. EDWIN EMERY SLOSSON, Science Service, 1701 Massachusetts Avenue, Washington, D. C

GEOLOGICAL SOCIETY

353D MEETING

The 353d meeting of the Geological Society of Washington was held in the auditorium of the Cosmos Club at 8 p.m. on Wednesday, January 12, 1921.

Regular Program

H. G. FERGUSON *Lode deposits of Manhattan, Nevada.* (Illustrated with lantern slides.)

C. N. FENNER. *Structural and volcanic geology of the Katmai region, Alaska* (Illustrated with lantern slides.) This paper has been published [1]

H. D. MISER· *Llanoria, the Paleozoic land area in Louisiana and eastern Texas.*

Evidence for a Paleozoic land area that occupied at least a part of Louisiana and eastern Texas has been published from time to time by different geologists. The most important paper on the subject is one by J. C. Branner, published in the American Journal of Science in 1897. Considerable information on the subject was obtained by the late Dr. A. H. Purdue and the writer during several years' study of the rock formations in the Ouachita Mountains and Arkansas Valley of Arkansas and Oklahoma, beginning in 1907. The following conclusions are based on this information and on the data published by other geologists. A land area which has been called Llano by Willis, Schuchert, and Ulrich, and Llanoria by Dumble and Powers, existed in Louisiana and eastern Texas during much, if not most, of the Paleozoic era, and during the Triassic and Jurassic periods of the Mesozoic era It varied in outline from time to time. It may have occupied a part of the area of the present Gulf of Mexico; at times it was doubtless connected with large land areas

[1] Journ Geol. 28: 569–606 1920

occupying at least much of central and northern Texas, southern Oklahoma, and southern Arkansas, and for short periods it may have extended eastward across the lower Mississippi Valley and joined the southwest end of the Appalachian area. It furnished most of the sediments that formed the clastic rocks of Pennsylvanian age in north-central Texas, and for those of Ordovician, Silurian, Mississippian, and Pennsylvanian age in the Ouachita Mountains and Arkansas Valley of Arkansas and Oklahoma. At times, as during the Devonian period, it had very little relief, but at other times, as during the Ordovician and Silurian periods and the Mississippian and Pennsylvanian epochs, it was mountainous It was depressed and entirely submerged during Lower Cretaceous time and later depressions carried the sea across it during Upper Cretaceous and Tertiary time, so that its rocks are now covered and entirely concealed by deposits of these ages. The discovery of pre-Cambrian schists directly beneath Cretaceous strata at Waco, Georgetown, Maxwell, San Antonio, and Leon Springs, Texas, suggests that the rocks of this old buried land area were similar to the crystalline rocks now exposed in the Piedmont Plateau of the eastern United States. If so, such rocks underlie the Cretaceous strata over much of Louisiana, eastern Texas, and perhaps adjoining areas to the south and east. Prominent structural features of the Gulf Coastal Plain, including the Preston anticline and Sabine uplift, may mark the location of some of the folds that were produced in the rocks on the old land area but that have undergone further movement since they were buried by Cretaceous and later sediments.

The results of future deep drilling in the Gulf Coastal Plain and further study of the Paleozoic and older rocks that are exposed around the borders of the Gulf Plain will add greatly to our imperfect knowledge of the old land area considered in this abstract. LAURENCE LAFORGE, *Secretary*

354TH MEETING

The 354th meeting was held in the lecture room of the Cosmos Club at 8 p.m on Wednesday, January 26, 1921.

Regular Program

D. F. HEWETT and E V. SHANNON: *Orientite, a new silicate of manganese and calcium. A.—Chemical properties* (SHANNON). *B.—Genesis and significance* (HEWETT)

As Mr. Shannon was out of the city the entire paper was presented by Mr. Hewett.

CHARLES BUTTS. *General results of recent work on the Mississippian of the Mississippi and Ohio valleys.*

J. B REESIDE and HARVEY BASSLER: *Phases of the Carboniferous and Triassic of southwestern Utah*

The geologic section of southwestern Utah includes rocks assigned to the Redwall limestone of Pennsylvanian age, the Supai and Coconino sandstones and Kaibab limestone of Permian age, the Moenkopi formation of Lower Triassic age, the Shinarump conglomerate and Chinle formation of Upper Triassic age. Comparison with the formations of areas to the southeast in Arizona and to the west and north in Nevada and Utah warrant the following conclusions: The Supai formation, passing from east to west and northwest, loses its red color and its shale members and merges with the Coconino to form a continuous massive yellow sandstone. The Kaibab limestone becomes thicker but has everywhere two cliff-forming limestone members separated by gypsiferous beds The red continental deposits of the Moen-

kopi pass with considerable interfingering into marine limestone. The Shinarump conglomerate and the Chinle formation maintain the same general character though quite variable locally. There is a pronounced hiatus at the base of the Moenkopi formation and another at the base of the Shinarump conglomerate. The age assignment of the Redwall, Kaibab, and Moenkopi formations is based on fossils; the assignment of the other formations is based on lithology and stratigraphic position only. W. T. THOM, JR., *Secretary.*

355TH MEETING

The 355th meeting was held in the lecture room of the Cosmos Club at 8 p.m. on Wednesday, February 9, 1921.

Regular Program

H. S. WASHINGTON. *The Deccan traps and other plateau basalts.*

R. C. WELLS: *Utilization of some western salines and saline lakes.* (Illustrated with lantern slides.)

R. S. BASSLER: *Paleontological work at the National Museum.* (Illustrated with lantern slides.)

LAURENCE LAFORGE, *Secretary.*

356TH MEETING

The 356th meeting of the Society was held in the lecture room of the Cosmos Club, at 8 p.m on Wednesday, February 23, 1921

Informal Communications

Dr. R. C. WELLS called attention to an inadvertent misstatement in his paper given at the previous meeting, and corrected the same.

Mr. LAURENCE LAFORGE gave a brief review of a paper by J. W. GREGORY on *The eskers of Ireland* and compared Professor Gregory's conclusions with those derived by American glacialists from the study of American eskers.

Regular Program

F. E. MATTHES. *Torrent channels and torrent levees in the Yosemite Valley.* (Illustrated with lantern slides.)

SIDNEY PAIGE · *Structure of the Homestake ore body* (illustrated with blackboard drawings and a wooden model) W. T. THOM, JR., *Secretary.*

357TH MEETING

The 357th meeting of the Society was held in the lecture room of the Cosmos Club at 8 p m. on Wednesday, March 9, 1921.

Regular Program

G. R MANSFIELD *Igneous geology of southeastern Idaho.* (Illustrated with lantern slides.)

A. I. JONAS and E. BLISS KNOPF *Stratigraphy of the metamorphic rocks of southeastern Pennsylvania and Maryland.*

The oldest metamorphic rocks of the southeastern border of the Piedmont Plateau are of pre-Cambrian age. The oldest formation is the Baltimore gneiss which is a composite gneiss comprising a thoroughly recrystallized biotite gneiss of undeterminate origin, possibly sedimentary, and a granitic intrusion that has interpenetrated the biotite gneiss and produced in many places an injection gneiss. The age of the granite has not yet been definitely determined and it is probable that the Baltimore gneiss has been cut by several granites of widely separated periods of intrusion.

The Baltimore gneiss is overlain by a series of sediments that are tentatively considered to be lower Cambrian. The base of this series is the Setters form-

ation which has hitherto been connected with the lower Cambrian fossiliferous Chickies quartzite of Pennsylvania. The work of the writers in the last two years has led them to conclude that the Setters formation is older than the Chickies quartzite. The Setters is overlain by the Cockeysville marble and the Wissahickon formation. An upper member of the Wissahickon formation that is less highly anamorphosed than the Wissahickon itself has been separated and named by the writers the Peters Creek schist The Peters Creek schist may represent the Harpers schist member of the Mont Alto quartzite of central Pennsylvania, in which case the metamorphic series comprising the Setters formation, Cockeysville marble, Wissahickon formation, and Peters Creek schist would be, as suggested by the writers, basal Cambrian. The Chickies quartzite in Pennsylvania has been shown to be 600 feet above the base of the Cambrian.

The Camargo schist is the name given by the writers to a porphyritic albite schist that comformably overlies a dolomite of probable Beekmantown age It forms the ridge that flanks Chester Valley on the south and comprises a portion of the formation formerly known as the Octoraro schist. It may represent the metamorphosed equivalent of the Normanskill shale found near Harrisburg, Pennsylvania The contact between the Wissahickon formation, Peters Creek schist, and the Camargo schist on the southwest border of the Camargo schist is a thrust fault called in the report the Drumore fault. It has been traced from Trenton, New Jersey, 150 miles southwest to Carroll County, Maryland Further work on the northeast continuation of this fault will help to establish a correlation between the geology of New England and of the Pennsylvania Piedmont formations.

O E. MEINZER *A map of Pleistocene lakes in the Basin-and-Range Province, and its interpretation* (Illustrated with lantern slides)

LAURENCE LAFORGE, *Secretary*

358TH MEETING

The 358th meeting was held in the lecture room of the Cosmos Club at 8 p m. on Wednesday, March 23, 1921

Regular Program

L. H ADAMS *The elastic properties of rocks.*

LAURENCE LAFORGE *Suggested modification of the doctrine of peneplanation in the light of recent knowledge.*

W T. THOM, JR., *Secretary.*

SCIENTIFIC NOTES AND NEWS

The thirty-eighth annual convention of the Association of Official Agricultural Chemists was held at the Washington Hotel on October 24-26

An Executive Board meeting of the American Engineering Council was held at the Cosmos Club at 10 a m. on Friday, September 30. Reports were presented from the Council's committees on licensing of engineers, classification and compensation of engineers, Employment Service, and other matters.

The following lectures have been given before the Physics Club of the Bureau of Standards since the last report in this JOURNAL (p 171). April 4, 1921, S. J. MAUCHLY *The methods and problems of atmospheric electricity;* May 27 (joint meeting with Mathematics Club), J S. AMES *Some appli-*

cations of hydrodynamics to aeronautics; October 17, ARTHUR L. DAY: *The study of California earth movements;* October 24, H. G. GALE: *Earth tides.*

The National Museum has received the Hubert Ward collection of African ethnologica from Paris, containing 19 sculptures by Mr. Ward and 2600 specimens of the arms and implements of the Africans of the Congo.

Dr. ELMER D. BALL, formerly Assistant Secretary of Agriculture, has entered upon his new duties as director of scientific work for the Department of Agriculture

Mr E F. HICKSON, until recently associate engineer in the department of technical control, American Writing Paper Company, Holyoke, Massachusetts, has returned to the Bureau of Standards as associate chemist.

Mr. C. E. MANGELS has resigned as chemist in charge of the commercial dehydration laboratory of the Bureau of Chemistry, U. S. Department of Agriculture, to accept the position of cereal chemist at the North Dakota Agricultural Experiment Station at Fargo, North Dakota

Dr. TRUMAN MICHELSON, of the Bureau of American Ethnology, returned in October from three and a half months' field work among the Fox Indians of Iowa.

Prof EDWARD E RICHARDSON discussed the *Philosophical aspects of Einstein's theory of relativity* before the Society for Philosophical Inquiry at the Public Library on October 1.

Dr. L I SHAW, assistant chief chemist of the Bureau of Mines, has been transferred to the Columbus, Ohio, ceramic experiment station of the Bureau, where he will have charge of some newly organized research on refractory products.

Dr GEORGE OTIS SMITH, director of the U. S. Geological Survey, addressed the annual meeting of the New York State Oil Producers' Association at Olean, New York, on September 31, on *The real value of oil.*

Dr. MERWIN PORTER SNELL, a member of the scientific staffs of the Smithsonian Institution and the Bureau of Fisheries in the years 1881–1889, died at his home at Stamford, Connecticut, on September 23, 1921, at the age of fifty-eight

Prof. A TADAKADATE, of the Imperial University of Tokyo, visited Washington in August, while on his way to the international conference on weights and measures at Paris

Dr. C. W WAIDNER, Chief of the Heat Division of the Bureau of Standards, has been appointed Chief Physicist of the Bureau to succeed the late E. B. ROSA.

Secretary CHARLES D. WALCOTT of the Smithsonian Institution returned from his field work in October. He reports the coldest and most disagreeable field season he had ever known in the Canadian Rocky Mountains. Paleontological and geological work was greatly hindered by mist and snow.

Messrs. J. E. WALTERS, F. W. SCHROEDER, and FRANK PORTER, chemists at the helium plant of the Bureau of Mines at Petrolia, Texas, have been transferred to the new cryogenic laboratory of the Bureau in Washington.

Dr. R. C. WELLS of the U. S. Geological Survey has been appointed treasurer of the Chemical Society of Washington to fill the vacancy caused by the removal of Dr. L. I. SHAW from Washington.

JOURNAL
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MATHEMATICS.—*On the correlation between any two functions and its application to the general case of spurious correlation* [1] LOWELL J. REED, Johns Hopkins University. (Communicated by Raymond Pearl.)

In problems where correlation methods are employed it is often necessary to determine the coefficient of correlation between one of the measured variables and some function of the others. In certain cases we need to go still further and determine the correlation between two different functions of the measured variables. Such cases arise where two different index numbers are correlated with each other or when an index number is correlated with one of the measured variables. In all problems of this type the coefficient of correlation may be found by computing the value of the function in question at each position for which the values of the variables themselves are known and then finding the correlation coefficient in the usual way. In a great many cases however there would be a considerable saving of labor if this coefficient could be determined directly from the means, standard deviations, and first order correlation coefficients of the variables themselves. The following general equation has been derived to accomplish this and it should prove to be of use in problems of the type outlined above The proof of the formula is too long to be given in the present paper, but will be published later, together with additional illustrations of its application

Let $x_1, x_2, \ldots x_n$ be a set of n variables,
and $x'_1, x'_2, \ldots \ldots x'_k$ be a second set of k variables.
Let $m_1, m_2, \ldots m_n$ be the means of the variables of the first set,
$\sigma_1, \sigma_2, \ldots \sigma_n$ be their standard deviations,
and $r_{x_1x_2}, r_{x_1x_3} \ldots \ldots r_{x_{n-1}x_n}$ be the coefficients of correlation between these variables taken in pairs.

[1] Papers from the Department of Biometry and Vital Statistics, School of Hygiene, Johns Hopkins University, No. 38 Received October 18, 1921

The same notation will be used for the means, standard deviations and coefficients of correlation of the primed variables.

Now let $y = f(x_1, x_2, \ldots\ldots x_n)$

and $z = f(x'_1, x'_2, \ldots\ldots x'_k)$

represent any two analytic functions of these two sets of variables. Then the correlation between these two functions is measured by

$$r_{yz} = \frac{\sum_{\alpha=1}^{n}\sum_{\beta=1}^{k} f_\alpha F_\beta \, r_{x_\alpha x'_\beta} \sigma_\alpha \sigma'_\beta}{\sqrt{\left[\sum_{\alpha=1}^{n}\sum_{\beta=1}^{n} f_\alpha f_\beta \, r_{x_\alpha x_\beta} \sigma_\alpha \sigma_\beta\right]\left[\sum_{\alpha=1}^{k}\sum_{\beta=1}^{k} F_\alpha F_\beta r_{x'_\alpha x'_\beta} \sigma'_\alpha \sigma'_\beta\right]}} \quad (1)$$

in which

$$f_\alpha = \frac{\partial f(m_1, m_2, \qquad m_n)}{\partial m_\alpha}$$

and

$$F_\beta = \frac{\partial F(m'_1, m'_2, \ldots \qquad m'_k)}{\partial m'_\beta}.$$

The derivation of equation (1) yielded as a by-product the expressions for the mean and standard deviation of any function of a set of variables in terms of the means, standard deviations and first order coefficients of correlation of the variables themselves.[3] These formulae are

(a) for the mean value of $y = f(x_1, x_2, \ \ldots \ . \ . \ldots x_n)$,

$$m_y = f + \tfrac{1}{2} \sum_{\alpha=1}^{n}\sum_{\beta=1}^{n} f_{\alpha\beta} \, r_{x_\alpha x_\beta} \sigma_\alpha \sigma_\beta \quad (2)$$

where $f = f(m_1, m_2, \ . \qquad m_n)$

and $f_{\alpha\beta} = \dfrac{\partial^2 f(m_1, m_2, \ldots \qquad m_n)}{\partial m_\alpha \partial m_\beta}$

(b) for the standard deviation of $y = f(x_1, x_2, \qquad \ldots x_n)$,

$$\sigma_y = \sqrt{\sum_{\alpha=1}^{n}\sum_{\beta=1}^{n} f_\alpha f_\beta \, r_{x_\alpha x_\beta} \sigma_\alpha \sigma_\beta} \quad (3)$$

[3] For another derivation of equations (2) and (3) see E. Czuber, *Über Funktionen von Variablen zwischen welchen Korrelationen bestehen.* Metron 1, No. 1, July, 1920.

Equations (1), (2) and (3) furnish a complete set of formulae for the determination of the means, standard deviations, and coefficient of correlation of any two functions of two sets of variables in terms of the means, standard deviations, and coefficients of correlation of the variables themselves.

It should be noted that, in the derivation of these formulae, all terms of the third or higher orders in the variables $\frac{\sigma_1}{m_1}, \frac{\sigma_2}{m_2}$, etc., were disregarded. Therefore in a practical problem when the standard deviation is large as compared with the mean the formula might not give a sufficiently close approximation to the true value of the correlation coefficient. In the majority of cases, however, the ratio of the standard deviation to the mean is a sufficiently small decimal so that disregarding its powers higher than the second can have no appreciable effect on the result.

To illustrate the use of equation (1) we may first apply it to the case of the correlation between ratios. Let the variables be x_1, x_2 and x'_1, x'_2 and the ratios be $y = \frac{x_1}{x_2}$ and $z = \frac{x'_1}{x'_2}$.

Then
$$f_1 = \frac{1}{m_2},\ f_2 = -\frac{m_1}{m_2^2}$$
$$F_1 = \frac{1}{m'_2}, F_2 = -\frac{m'_1}{m_2'^2}.$$

Substituting these values in (1) and replacing $\frac{\sigma_1}{m_1}$ by v_1, $\frac{\sigma_2}{m_2}$ by v_2, etc., we have

$$r_{yz} = \frac{r_{x_1x_1'}v_1v_1' - r_{x_1x_2'}v_1v_2' - r_{x_2x_1'}v_2v_1' + r_{x_2x_2'}v_2v_2'}{\sqrt{(v_1^2 + v_2^2 - 2r_{x_1x_2}v_1v_2)(v_1'^2 + v_2'^2 - 2r_{x_1'x_2'}v_1'v_2')}}. \tag{4}$$

This is Pearson's[3] well known formula for the coefficient of correlation of two indices or ratios. Formulae for the means and standard deviations of y and z can be obtained from equations (2) and (3).

They are $m = \frac{m_1}{m_2}\,[1 + v_2^2 - r_{x_1x_2}v_1v_2]$

and $\sigma_y = \frac{m_2}{m_1}\sqrt{v_1^2 + v_2^2 - 2r_{x_1x_2}v_1v_2}$.

[3] PEARSON, K. *On a form of spurious correlation which may arise when indices are used in the measurement of organs* Proc. Roy. Soc., London 60. 1896.

As a second illustration let us consider the correlation between products of the variables.

Let $y = x_1 x_2$ and $z = x_1' x_2'$.

Then from (1) we have

$$r_{yz} = \frac{r_{x_1x_1'}v_1v_1' + r_{x_2x_1'}v_2v_1' + r_{x_1x_2'}v_1v_2' + r_{x_2x_2'}v_2v_2'}{\sqrt{(v_1^2 + v_2^2 + 2r_{x_1x_2}v_1v_2)(v_1'^2 + v_2'^2 + 2r_{x_1'x_2'}v_1'v_2')}}. \tag{5}$$

The mean and standard deviation, derived from equations (2) and (3), are given by

$$m_y = m_1m_2\,[1 + r_{x_1x_2}v_1v_2]$$

and

$$\sigma_y = m_1m_2\sqrt{v_1^2 + v_2^2 + 2r_{x_1x_2}v_1v_2}.$$

If we consider x_2' to be constant we have a special case of formula (5) of considerable importance, that is, the case of the correlation between the product of two variables, $y = x_1x_2$, and some third variable $z = x_1'$.

For this case

$$r_{yz} = \frac{r_{x_1x_1'}v_1 + r_{x_2x_1'}v_2}{\sqrt{v_1^2 + v_2^2 + 2r_{x_1x_2}v_1v_2}} \tag{6}$$

Formulae (5) and (6) will be found useful in those cases in which the product of two measurable linear functions is used as an index number for a surface that cannot be directly measured, as is the case for instance in dealing with the surface of the human body.

The problem of finding the coefficient of correlation between some function of a set of variables and some other measured variable is so common that it is advisable to consider the form taken by equation (1) in this case. We would have

$$y = f(x_1, x_2, \qquad x_n) \text{ and } z = F(x_1') = x_1'.$$

Then

$$r_{yz} = \frac{\sum_{\alpha=1}^{n} f_\alpha r_{x_\alpha x_1'}\sigma_\alpha.}{\sqrt{\sum_{\alpha=1}^{n}\sum_{\beta=1}^{n} f_\alpha f_\beta r_{x_\alpha}\sigma_\alpha\sigma_\beta}}. \tag{7}$$

It should be noted that the standard deviation of the variable x_1' does not enter this equation directly, the only factor involving x_1' being the correlation coefficient $r_{x_\alpha x_1'}$. Equation (6) which was derived as a special case of formula (5) might have been obtained directly from (7).

SPURIOUS CORRELATION

Attention was first called to the subject of spurious correlation in a paper by Pearson[4] where he considered the case of the spurious correlation between two ratios of the form $\frac{x_1}{x_3}$ and $\frac{x_2}{x_3}$. Pearson showed that although x_1, x_2, and x_3 were uncorrelated variables there would be correlation between the two ratios $\frac{x_1}{x_3}$ and $\frac{x_2}{x_3}$, this correlation arising from the fact that x_3 is common to the two indices Since this correlation exists where there is no correlation between x_1, x_2 and x_3 he gave it the name of *spurious correlation*. The arguments used by Pearson in connection with the spurious correlation between ratios will hold in the case of correlation between any two functions, and a general definition of spurious correlation might be given as follows

Though no correlation exists between any two of a set of variables there will still exist correlation between any two functions of these variables whenever these two functions have any of the variables in common The correlation existing under these conditions will be called *spurious correlation*

A general formula for spurious correlation may be derived directly from equation (1). Using, as before, $y = f(x_1, x_2, \quad x_n)$ and $z = F(x_1', x_2' \quad x_k')$ we shall have spurious correlation only when some of the variables $x_1, x_2, \quad x_n$ are identical with some of the variables $x_1', x_2' \quad x_k'$.

Let
$$\begin{aligned} x_1 &= x_1' \\ x_2 &= x_2' \\ (& \quad) \\ x_h &= x_h' \quad \text{where } h \overline{<} k \quad \text{and } h \overline{<} n. \end{aligned}$$

Then, from the definition of spurious correlation, $r_{x_\alpha x_\beta} = 0$ except for the cases where $\alpha = \beta \overline{<} h$ in which event $r_{x_\alpha x_\beta} = 1$.

[4] *Op. cit*

Thus we shall have

$$\rho_{yz} = \frac{\sum\limits_{\alpha=1}^{k} f_\alpha F_\alpha \sigma_\alpha^2}{\sqrt{\left[\sum\limits_{\alpha=1}^{n} f_\alpha^2 \sigma_\alpha^2\right]\left[\sum\limits_{\alpha=1}^{k} F_\alpha^2 \sigma_\alpha'^2\right]}} \tag{8}$$

where ρ is used to denote spurious correlation.

All of the special cases considered under equation (1) will exhibit one or more forms of spurious correlation.

For example, when $y = \dfrac{x_1}{x_2}$ and $z = \dfrac{x_1'}{x_2'}$ we may have three different cases of spurious correlation:

(a) when the fractions have the same denominator, *i. e.*, $x_2 = x_2'$
(b) when the denominator of one is the same as the numerator of the other, *i. e.*, $x_2 = x_1'$
(c) when the fractions have common numerators, *i. e.*, $x_1 = x_1'$.
The formulae for the spurious correlation in these three cases are

(a) $$\rho_{yz} = \frac{v_2^2}{\sqrt{(v_1^2 + v_2^2)\,(v_1'^2 + v_2^2)}} \tag{9}$$

(b) $$\rho_{yz} = \frac{-v_2^2}{\sqrt{(v_1^2 + v_2^2)\,(v_2^2 + v_2'^2)}} \tag{10}$$

(c) $$\rho_{yz} = \frac{v_1^2}{\sqrt{(v_1^2 + v_2^2)\,(v_1^2 + v_2'^2)}}. \tag{11}$$

Of these three cases the first one is the one which usually arises in practice.

When the functions considered are products they may have a common factor so that $y = x_1x_2$ and $z = x_1'x_2$.
Then

$$\rho_{yz} = \frac{v_2^2}{\sqrt{(v_1^2 + v_2^2)\,(v_1'^2 + v_2^2)}}. \tag{12}$$

The foregoing illustrations show a few of the equations for specific cases of spurious correlation that can be derived from the general formula. Similar expressions may be obtained from equation (8) for the spurious correlation between any two functions. The value of the spurious correlation involved should always be considered when drawing conclusions from the coefficient of correlation of any two index numbers regardless of their functional form.

PHYSICS.—*The discontinuity of resistance preceding supraconductivity.*[1] P. W. BRIDGMAN, Jefferson Physical Laboratory, Harvard University.

The phenomenon of supraconductivity has to the present time been found in mercury, tin, thallium, and lead.[2] The resistance of the first three of these metals changes discontinuously by a factor of the order of 10^8 at a definite critical temperature. This temperature is 4.2° K. for Hg, 3.78° for Sn, and 2.3° for Tl. The probability is that the resistance of lead decreases discontinuously in the same way on entering the supraconducting state, but the temperature has not yet been definitely measured because it is in the range between 4.3° and 20° which cannot as yet be controlled by a suitable cryostat. Onnes estimates that the temperature of discontinuity of lead is about 6° K.

The discontinuous change of resistance has often been supposed to be in some way intimately connected with the supraconducting state. For instance, J. J. Thomson has a theory accounting for the sudden disappearance of resistance.[3] Now if such a phenomenon of discontinuity occurred at an ordinary temperature, one would almost certainly look for a polymorphic change as the cause of the discontinuity. The thesis which I wish to support in this paper is that the discontinuous change of resistance on entering the supraconducting state is also a mark of a polymorphic change, and that discontinuity and supraconductivity are not as intimately related as sometimes supposed, but are due to quite distinct mechanisms.

According to this view, the normal condition in an individual crystal grain of any metal at very low temperatures is supraconductivity. Any ordinary metal is an aggregate of crystal grains in ran-

[1] Received October 12, 1921.

[2] C. A. CROMMELIN. Phys. Zeitschr. 21: 274, 300, and 331. 1920.

[3] J. J. THOMSON. Phil. Mag. 30: 192–202. 1915.

dom orientation with respect to each other. Between the crystalline grains there are localities in which the atoms are not regularly arranged, but the metal is more or less amorphous in character, and in these localities there is a residual resistance that persists to absolute zero. The curve of resistance against temperature of such a metal becomes asymptotic at absolute zero to a low but finite resistance Suppose, however, the metal is one having a polymorphic transition in the region of low temperatures. Normally the growth of the polymorphic form will start from a single nucleus, so that after the transition the wire will consist of a single crystalline grain without amorphous regions On raising the temperature again beyond the transition point the wire recovers its original crystalline structure and its original resistance. The recovery of the original structure is of course evidence of some sort of residual nuclear structure in the low-temperature modification. This appears at first sight not what one would expect, but it is exactly what is found in the transition of ordinary polymorphs at higher temperatures.

Apart from its intrinsic probability and the fact that this view does not need to invoke a new mechanism to explain the discontinuity, there is considerable evidence in its favor. In the first place the original belief that supraconductivity was in some way connected with the purity of the metal, and that only those metals would show that it could be obtained in a state of extreme purity, has not turned out to be true. It has been found that amalgams show the effect, and that gold, which has been obtained in a higher state of purity than lead or tin, does not show the effect.

The appearance of supraconductivity is to a certain extent capricious, and occasionally samples are prepared which for some unknown reason do not become supraconducting. This is to be explained by some accident of structure or handling which caused the growth of the polymorphic form to start from more than one nuclear center, so that regions of separation between the different grains persist beyond the transition point.

The temperature of the discontinuity of resistance is known to be depressed when the current in the conductor is increased, and also when the conductor is placed in a magnetic field. Silsbee[4] has shown in this JOURNAL that the probability is high that the phenomena are not unrelated, but that the threshold value of the current is that at which the magnetic field within the wire due to the current itself

[4] F. B. SILSBEE. This JOURNAL 6: 597–602. 1916.

reaches the threshold value. It is sufficient to explain, therefore, the effect of the magnetic field on the temperature of discontinuity. I show in the following that the temperature of a polymorphic transition is altered by a magnetic field, so that again we do not have to invoke any unusual or new connection between the conduction mechanism at low temperatures and the magnetic field in order to explain the facts. In addition to the effect on the temperature of discontinuity, the magnetic field exerts a large effect on the resistance above the transition point; we are not here concerned with this effect, but merely with the relation between the field and the discontinuity (or polymorphic transition).

Since it requires energy to magnetize a body, a simple thermodynamic argument is capable of finding the effect of a magnetic field on a transition temperature. The argument runs precisely like that used in deducing Clapeyron's equation for the connection between an increment of pressure and the change in the temperature of a transition point The classical Clapeyron's equation is

$$\frac{d\tau}{\tau} = \frac{(v_2 - v_1)dp}{\lambda}$$

This is obtained by a direct application of the second law of thermodynamics to a cycle consisting of a transition from phase (1) to phase (2) at temperature τ and pressure p, transfer of the substance to temperature $\tau + d\tau$ and pressure $p + dp$, transition here in the reverse direction from phase (2) to phase (1), and transfer of the substance back to the initial temperature and pressure. In the equation above, λ is the latent heat absorbed when phase (1) passes to (2), and $(v_2 - v_1)dp$ is the work received by the external forces during the cycle

The analysis is precisely similar in the case of a magnetic field except that the work done by the external forces, which in the previous case was work done by the external pressure, now becomes work done by the magnetic forces The cycle consists of a transition from phase (1) to (2) at temperature τ and magnetic field H, transfer of the substance to temperature $\tau + d\tau$ and field $H + dH$, transition in the reverse direction from (2) to (1), and transfer of the substance back to the initial temperature and field. In Clapeyron's equation as written above we merely have to replace $(v_2 - v_1)dp$ by the work done during the cycle on the magnetic forces. Now the work done by the magnetic forces during a change of magnetization is HdI.

During the first transition H remains constant, but I changes from k_1H to k_2H. Hence the total work during the transition is $H^2(k_2 - k_1)$. During the transfer from τ and H to $\tau + d\tau$ and $H + dH$, the susceptibility remains constant, but H changes by dH. The work during this stage is k_2HdH. Similar expressions give the work during the other two stages of the cycle. The total work of the cycle is $HdH(k_1 - k_2)$, and the equation for which we are searching is therefore

$$\frac{d\tau}{\tau} = \frac{(k_2 - k_1)HdH}{\lambda}.$$

Under ordinary conditions the change of transition temperature in a magnetic field is very small, but at low temperatures the effect may become large. For the energy content of a body decreases as the fourth power of the absolute temperature, so that λ varies as τ^4, and if Curie's law is true, the susceptibility varies inversely as the temperature, so that, other things being equal, the change of transition temperature in a magnetic field varies inversely as the fourth power of the temperature.

The formula as given above applies to an infinitesimal temperature range. When approaching zero, the actual change of temperature in a finite field must be found by an integration of this equation. If we make the assumptions of the last paragraph, we have

$$\tau^4 d\tau = \text{Const.}\, HdH$$

which on integration goes into

$$\tau^5 - \tau_0^5 = \text{Const.}\, H^2.$$

The data by which this equation may be checked are meager, but they are at least consistent with it. In default of measurements of energy content and susceptibility at low temperatures, the equation could be checked from measurements of the normal temperature of discontinuity and the corresponding temperature in two different magnetic fields. The only metal for which Onnes gives the effect of two different magnetic fields on the temperature of discontinuity is lead, and we have already mentioned that the normal temperature for this substance has not been accurately measured. However it is interesting to show that the data for lead are at least consistent with this point of view. From a diagram given by Onnes[5] (he does not publish the values numerically) I deduce that the temperature of discontinuity in a field $H = 930$ is 4.25°, and in a field 1130 is

[5] H. Kamerlingh Onnes. Proc. Amst. Acad Sci. 16: (2) 991. 1914.

2.0°. The rapid fall of temperature with comparatively slow rise of field is what we would expect from the equation. Now if we assume that the equation above is true, and find τ_0 by substituting the known values, we shall get 5.3° for the normal transition temperature, against the estimate of Onnes of 6°. This I believe must be considered to be within possible experimental error.

Another detail of the behavior of the magnetic field is also consistent with this view. Onnes found that at a fixed temperature the threshold value of the field was slightly higher for a field parallel to the wire than for one transverse to it. The probable reason is that when the field is transverse there are regions inside the wire itself where the circumferential field due to the current in the wire is in the same direction as the external applied field, whereas this is not the case for the longitudinal field. Hence in the transverse case the maximum field is greater than the measured field, and the applied field does not have to be raised so high in order that the critical value may be reached.

The temperature of transition of the four metals hitherto measured is depressed in a magnetic field. This means that the phase stable at the lower temperature has the greater susceptibility. It does not appear to me whether there is any reason why this should be universally true, or whether it is possible that there may be substances whose temperature of discontinuity is raised in a magnetic field.

This view of the discontinuity as due to a polymorphic change ought to be capable of independent experimental verification. It should be possible to detect discontinuous changes in other physical properties—so far as I know the search has not been made for these—and it may be possible to realize supraconductivity in metals which do not normally show it, by recrystallizing a wire at higher temperatures, as can now be done for tungsten, before subjecting it to low temperatures.

PETROLOGY.—*The granites of Washington, D. C.*[1] HENRY S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington.

The granites of the District of Columbia and its vicinity belong to the great belt of Archean intrusives (mostly granite with smaller

[1] Received October 21, 1921. Presented before the Geological Society of Washington October 26, 1921.

amounts of diorite, gabbro, diabase, and pyroxenite) that extends along the Piedmont Plateau from Georgia through Maryland, and northward into New England. The granites and other igneous rocks of the District have been little studied; or, at least, little detailed information regarding them has been published. Merrill,[2] Williams,[3] and Keith[4] give us but very summary descriptions, although Keyes[5] describes in great detail the related and closely similar granites of central Maryland. Only one analysis, and that one incomplete, of a fresh Washington granite has been published, together with one of a weathered granite.

Mr. L. H. Adams of this Laboratory selected a specimen of the Tilden Street granite for his study of the compressibility of rocks. I made a chemical analysis of this for him, and was thus led to analyze other specimens from the District. The results of these analyses, accompanied by brief petrographic descriptions, are given in this paper, in the hope that they may be of use to some geologist who in the future will study the region thoroughly No attempt is made here to discuss, even summarily, the structural geology or the relations of the granites to the other igneous rocks or to the intruded gneisses (fig. 1).

Types —Keith refers the granite of the Washington Folio to three classes: granite-gneiss, granitic dikes in the gneiss, and intrusive granite All the specimens described in the present paper are of intrusive granite, so far as has been ascertained, although some of them are markedly foliated or gneissoid. Whether some of these last belong in reality to the granite-gneiss or to the Carolina gneiss must be left to the structural investigator.

The granites studied may be referred to two fairly distinct types, biotite granite and muscovite-biotite granite. Although all the specimens of granite show evidence of crushing and other results of pressure, non-foliated or slightly foliated forms of each occur, and from these they pass into intensely foliated, gneissoid forms. It would appear that the two extremes of the types are quite distinct chemically, the type with muscovite being considerably higher in silica than the type with biotite alone, but that they are connected by intermediate forms.

[2] G P MERRILL Bull. Geol Soc. Amer. 6: 321. 1895. *Rocks, rock-weathering and soils*, p. 200. 1897

[3] G. H WILLIAMS U S Geol. Survey Ann. Rep. 15: 657–684 1895.

[4] A. KEITH. U. S Geol. Survey Folio 70 (Washington Folio) 1901.

[5] C. R KEYES. U. S. Geol. Survey Ann Rep 15: 685–737. 1895.

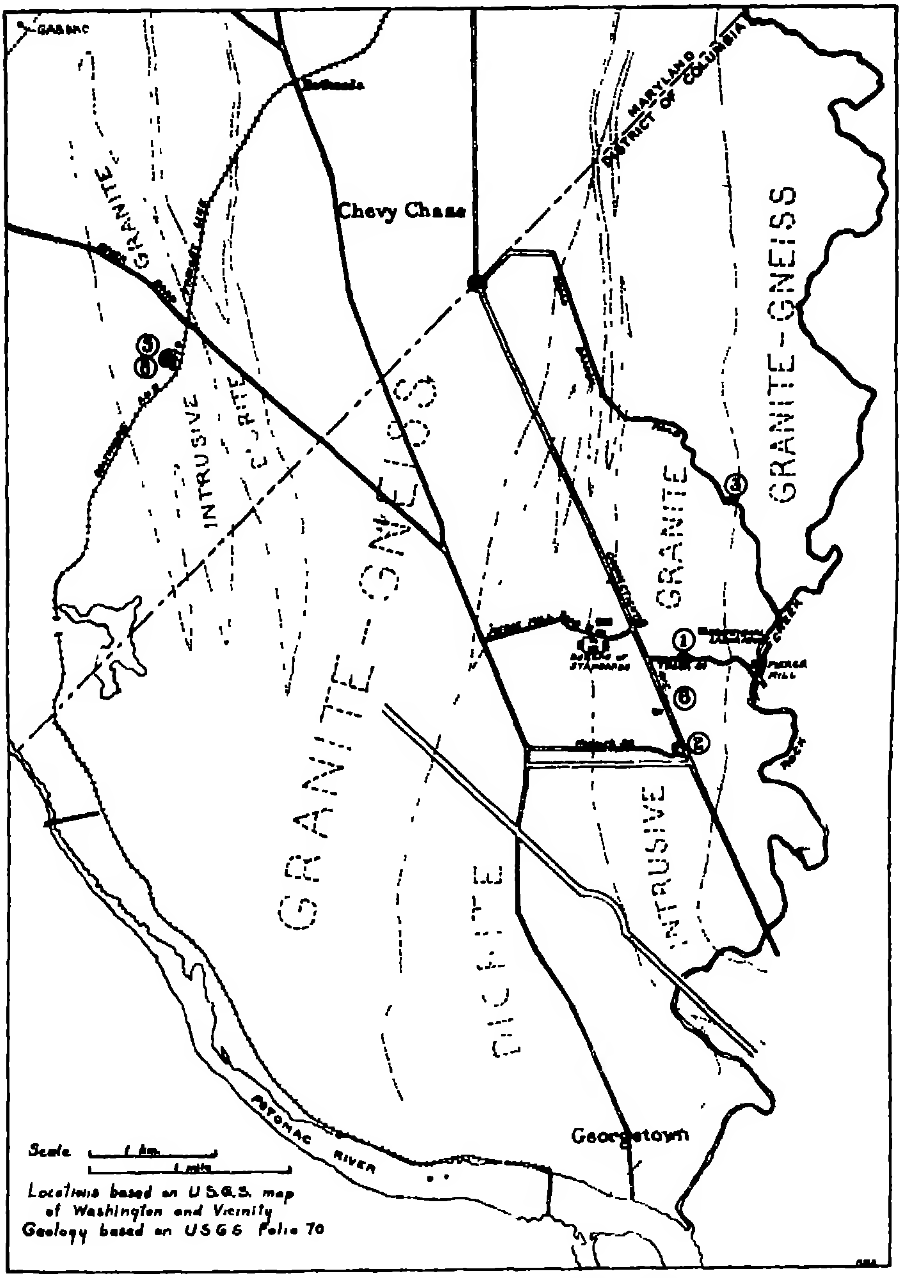

Fig 1. Geological map showing location of analyzed specimens of granite.

BIOTITE GRANITE (TILDEN STREET TYPE)

Megascopic characters—This granite is of a general light gray color, almost white in the mass, and is generally quite coarse grained. Glistening, black plates of biotite are very conspicuous, the thin streaks being up to 1 or 2 cm. long. These may be quite uniformly distributed, but without definite orientation, as in specimens from Newark Street; or arranged in roughly parallel position, producing a markedly foliated texture, as in the Tilden Street and Pierce Mill Road quarries. This foliation becomes more intense in two old quarries on Broad Branch Road, about 1.3 kilometers north of Pierce Mill. The spur on which are situated the Geophysical Laboratory and the Holy Cross Academy seems to be composed wholly of this (slightly foliated) type. The weathering of this granite has been described by Merrill in the works cited above. This biotite granite appears to be the most abundant type in and around the District.

Microscopic characters.—In thin section this type is seen to be composed chiefly of untwinned, alkali feldspar and quartz, with subordinate oligoclase, epidote, biotite, and muscovite. There is no hornblende, no allanite was seen, and there are rare, small grains of magnetite and prisms of apatite. The texture is cataclastic, but not uniformly so. Much of the area of the section is rather coarsely granoblastic, composed almost wholly of irregular grains of alkali feldspar and quartz, which show some undulatory extinction. A few smaller anhedra of finely twinned oligoclase occur here and there, and there is considerable brownish biotite in irregular shreds, with an occasional small plate of muscovite, some of which is intergrown with the biotite and is primary. These areas contain no epidote.

Between these areas are streaks and patches of finer grained, crushed material. This is mostly untwinned alkali feldspar, with fewer grains of quartz and oligoclase, and a little biotite. These areas contain considerable secondary epidote in the form of small, colorless, euhedral or subhedral crystals and prisms, which occur in the feldspar and are frequently agglomerated into clusters. There is also a little secondary muscovite in very small shreds and plates. No allanite was seen with any of the epidote; this is somewhat remarkable in view of its common occurrence in the Maryland granites described by Keyes, who regards the epidote as primary. A large number of traverses across thin sections of the Tilden Street granite, including areas of both kinds of material, gave the mode shown in table 1, in volumes and weights.

TABLE 1. MODE OF BIOTITE GRANITE FROM TILDEN STREET

	Vol	Wt
Quartz	29	29 0
Orthoclase	53	51 0
Oligoclase	4	4 0
Biotite	7	7.6
Muscovite	1	1 0
Epidote	6	7 4
	100	100 0

Composition.—Two specimens of this type were analysed. That from the Tilden Street quarry (analysis (1) in table 2) was used by Mr. L. H. Adams for the determination of its compressibility and density. The density was found to be 2.739 at 30° C. The other (2), was taken from a small quarry recently opened between Newark and Ordway Streets near and west of Connecticut Avenue. This is somewhat finer grained and less foliated than the Tilden Street granite. An analysis (3), of the Broad Branch biotite granite, described by Merrill, and one of the Rowlandsville, Maryland, granite (4), described by Williams and by Keyes, are given for comparison. (See first four analyses of table 2, and map, figure 1.)

Norm.—These are analyses of rather "basic" granites, low in silica, high in lime, and not high in alkalies, with a tendency to dominant soda. Their chemico-mineral characters are well shown in their norms, given in table 3, that of No. (3) being omitted, as the analysis is incomplete

The resemblance between the three is manifest in the symbols. All are near the border between classes I and II, all are in the quardofelic order and in the alkalicalcic rang. The two from Washington are sodipotassic, but near the border of the dosodic subrang, while that of Rowlandsville is dosodic.

Comparing the norm of No. (1) with its mode, certain discrepancies are evident. Much of the abundant anorthite of the norm enters into the modal epidote, along with some of the ferric oxide. As epidote has an excess of CaO over $(Al,Fe)_2O_3$ this will liberate some alumina for the biotite, in which the normative hypersthene finds place. The alkali feldspar is evidently a highly sodic orthoclase. From the two sets of figures, however, even after all possible readjustments have been made, it would appear that the sections used for the Rosiwal determination of the mode were made in portions of the rock which contained more alkali feldspar and less biotite than

TABLE 2. GRANITES OF WASHINGTON, D C

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
SiO_2	67 46	69.19	69 33	66 68	71 92	71 66	72 57	99 43	93 38	96 16
Al_2O_3	14 22	14 88	14 33	14 93	13 24	13 97	15 11	0.11	3 09	1 31
Fe_2O_3	1 33	1 30	n. d.	1.58	1 82	1 34	1 02	0 21	0 72	0.02
FeO	3 24	2 64	3 60	3 32	2 01	1 92	0 59	0 12	n d.	0.09
MgO	2 85	2 06	2 44	2 19	1 14	1 29	0 30	0.03	0 43	0.03
CaO	3 72	3 36	3 21	4 80	1 45	1 15	1 65	0 05	0 34	trace
Na_2O	2 88	3 28	2 70	2 65	3 81	3 40	3 92	0 03	0 50	0 56
K_2O	2 84	3 02	2 67	2 05	4 54	3 94	4 33	0 06	1 32	0 30
H_2O +	0 57	0 18	1 22	1 00	0 10	0 80	0 47	0 05	n. d.	0 51
H_2O —	0 12	0 09	——	0 16	0 08	0 33	——	0 02	n d	0 08
TiO_2	0 47	0 42	n d	0 50	0 36	0 79	n d.	none	0 12	n d.
ZrO_2	none	n. d.	n d	n d.	none	n d.	n d	n d	n d.	n d.
P_2O_5	0 31	0 14	0 10	0 10	0 23	0 14	n d	none	none	n d.
S	0 02	n d	n d	n d	0 04	n d	n d	n d	n d.	n. d
MnO	0 08	0 12	n d.	0 10	0 08	n d	n d	none	n d	n d
BaO	0.04	n d	n d	0 08	none	n d	n d	n d	n d	n d.
	100 15	100 68	99 60	100 32	100 74	100 73	99 96	100 11	99 90	99 06

(1) Biotite granite, Tilden Street quarry WASHINGTON analyst
(2) Biotite granite, Newark Street quarry WASHINGTON analyst.
(3) Biotite granite, Broad Branch Road quarry PACKARD analyst G P MERRILL, Bull Geol Soc Amer. 6: 321. 1895
(4) Biotite granite, Rowlandsville, Maryland HILLEBRAND analyst G H WILLIAMS, U S Geol Survey Ann Rep 15: 672. 1895.
(5) Muscovite-biotite granite, River Road quarry WASHINGTON analyst.
(6) Muscovite-biotite granite (foliated) Rodman Street opening, WASHINGTON analyst
(7) Muscovite-biotite granite Guilford, Maryland HILLEBRAND analyst. C R. KEYES, U S Geol Survey Ann Rep 15: 716 1895
(8) Quartz vein in granite, River Road quarry WASHINGTON analyst.
(9) Northfieldite, Pelham, Massachusetts E T ALLEN analyst B K. EMERSON, Amer Journ Sci 40: 215 1915.
(10) Quartzose border of granite A R DWERRYHOUSE analyst DWERRYHOUSE, Quart Journ Geol Soc 65: 64 1909.

TABLE 3. NORMS OF BIOTITE GRANITE

	(1)	(2)	(4)
Quartz	26 46	27 06	28 26
Orthoclase	16 68	17 79	12 23
Albite	24 63	27 77	22 53
Anorthite	16 40	15 85	22 52
Corundum	0 30	0 41	none
Diopside	——	——	1 19
Hypersthene	11 32	8 63	8 90
Magnetite	1 86	1 86	2 32
Ilmenite	0 91	0 76	0 91
Apatite	0 67	0 34	0 34

(1) Tilden Street. Symbol (I)II.4.''3.3(4).
(2) Newark Street. Symbol I(II).4.(2)3.3(4).
(4) Rowlandsville. Symbol (I)II.''4.3.''4.

the larger and more representative amount of material used for the analysis.

MUSCOVITE-BIOTITE GRANITE (RIVER ROAD TYPE)

A binary granite, containing about equal amounts of muscovite and biotite, occurs in and near Washington, but is less abundant than the biotite granite. Similar general quantitative relations between the types seem to hold good in the Maryland granites as described by Williams and Keyes, as well as in the granites of Georgia, as described by Watson.[6]

Megascopic characters.—The binary granite occurs in massive, unfoliated form, as at the River Road quarry of the Bethesda Blue Granite Company, about 1.3 km. northwest of the District line, in Maryland, which is being actively worked. The rock of this quarry may be regarded as typical An intensely and finely foliated, gneissoid form was collected by Dr. M. Aurousseau of this Laboratory at a small opening on Connecticut Avenue, near the corner of Rodman Street. This last was thought by him to be a highly foliated portion of the granite exposed at Newark Street, about 0 3 kilometer to the south, but the exact relations are unknown.

The River Road granite is light gray and of finer grain than the Tilden Street type. Small plates of both muscovite and biotite are abundant; they are arranged in small, irregular streaks and patches, producing a slightly foliated structure. The Rodman Street specimen is darker gray, much finer grained, and with a highly foliated, gneissoid texture.

Microscopic characters —In thin section the two are much alike, except for the distinctly foliated arrangement shown in sections of the Rodman Street granite cut across the foliation. The texture is highly cataclastic, both rocks giving evidence of intense crushing and some recrystallization. Irregular, fragmental granules of quartz and alkali feldspar are abundant, with few of finely twinned oligoclase. Irregular shreds of biotite, which is a decidedly greener brown than in the other type, and tables of primary muscovite, are common. The two micas are frequently intergrown, the muscovite being generally included in the biotite, and these larger crystals of muscovite are clearly primary. There is no amphibole nor magnetite, and small grains of epidote are very rarely seen. Small irregular areas composed of grains of quartz and highly crushed and sericitized

[6] T. L. WATSON, Amer. Geol. 27: 199. 1901, Georgia Geol Survey, Bull 9-A. 1902.

orthoclase are rather common; the small plates of secondary muscovite in these show a tendency to a latticed arrangement. Rosiwal measurements on the sections of the River Road granite gave figures corresponding to 7.2 per cent of biotite and 7.4 per cent of muscovite by volume. The River Road granite resembles that of Guilford, Maryland, as described by Keyes.

Composition.—Chemical analyses were made of specimens both from the River Road quarry (5) and the Rodman Street opening (6), and the results are given in table 2, together with an analysis of the Guilford, Maryland, granite (7), described by Keyes.

The two Washington muscovite-biotite granites closely resemble each other, that of the River Road quarry being slightly higher in both alkalies, and with inverse proportions of magnesia and lime. In their general chemical characters, and in their modal details, they are very like the common granites of New England, Maryland, Virginia, South Carolina, and Georgia.[7] The Guilford granite is slightly higher in silica and alumina,[8] and lower in magnesia; it is probable that this has a higher content of muscovite than the Washington granites.

Norm.—The norms, shown in table 4, call for no special comment. As shown by the symbols the three granites fall in toscanose, the subrang to which belong more of the igneous rocks than to any other, and in which most of the Piedmont granites fall.

QUARTZOSE PHASES

The granite of the River Road quarry contains some small stringers and veinlets of a white, finely granular, highly quartzose aplite, with sharp boundaries between the veins and the granite. The microscope shows that this material is composed almost wholly of small, irregular, interlocking grains of quartz, with very few of orthoclase, and rare small muscovite flakes. The quartz and feldspar grains show slight undulatory extinction. The analysis (8) of the quartz aplite of one of these veinlets shows that it is almost pure quartz, with about one per cent of feldspar and mica. This quartz aplite closely resembles the northfieldite described by Emerson,[9] except that the latter is rather more coarse grained, contains more feldspar and mica, and is more decidedly pegmatitic. A highly

[7] Cf. *Chemical analyses of igneous rocks*, 1884–1913. U. S. Geol. Survey Prof. Paper 99: 167–175.

[8] The higher alumina is caused, in part, by the non-determination of titanium and phosphorus oxides.

[9] B. K. Emerson. Amer. Journ. Sci. 40: 212. 1915.

quartzose rock found by J. E. Spurr near Helvetia, Arizona, but as yet undescribed, also is closely similar.[10] This was provisionally named arizonite by Spurr and me, but Emerson's name, northfieldite, would seem to have priority. As pointed out by Emerson, as well as by Spurr in the manuscript of his paper, such rocks are to be considered as the ultra-silicic, hydrated portions of the magma, which were the last to solidify in shrinkage cracks of the still hot and recently solidified mass.

GENERAL RELATIONS

Although this paper aims only to present the results of several analyses of the granites of Washington, as a contribution to our scanty knowledge of the petrology of the District of Columbia, yet a few remarks may be permitted on the general relations of the igneous rocks. The published data are very few, and my personal acquaintance with the field geology is of the slightest. It would seem, however, that there is possibly an approach to regularity in the structural arrangement of the igneous rocks of the batholithic (?) intrusive mass.

Referring to the Historical Geology Sheet of Folio 70, we see that a broad band of "granite-gneiss" cuts obliquely across the western portion of the area. This has a mode much like that of the River

TABLE 4. NORMS OF MUSCOVITE-BIOTITE GRANITE

	(5)	(6)	(7)
Quartz	27.82	32.16	28 68
Orthoclase	26 69	23 35	25 58
Albite	31.96	28 82	33 01
Anorthite	5 28	5 00	8.34
Corundum	0.20	2 24	0.92
Hypersthene	4 75	4 26	2.12
Magnetite	2.32	1 86	0 93
Ilmenite	0 61	1 52	——
Apatite	0 67	0 34	——

(5) River Road quarry. Symbol I″ 4 (1)2 3.
(6) Rodman Street opening. Symbol I″.(3)4.″2.3.
(7) Guilford, Maryland Symbol I 4 2 3″.

Road binary granite, but the chemical analysis[11] of one specimen much resembles that of the biotite granite of Tilden Street. Toward the northern part of this gneiss (within the Washington quadrangle) are two long areas of biotite granite, with some muscovite-biotite

[10] An analysis of this is given in U. S. Geol. Survey Prof. Paper 99: 51.

[11] Cf. G. H. WILLIAMS, *op. cit.* p. 670; also U. S. Geol. Survey Bull. 591: 49. 1915.

granite. Whether these are part of the same intrusive complex as the granite-gneiss I am unable to say. In the northwestern corner of the sheet we meet with a broad band of diorite, as well as a narrow streak and what are apparently small outcrops cutting the Carolina gneiss along Scott's Run. Diorite is also met with in Georgetown and in the old tunnel of Rock Creek Park, analyses of which have been published.[12] A small exposure of "gabbro" occurs about 2 kilometers west of Bethesda, in the northwest part of the quadrangle. Few exposures of diorite and none of gabbro seem to have been found or recorded in the central granitic part of the igneous area. Thus, although the structural relations are apparently somewhat complex, and their study and interpretation in the field offer difficulties, as Keith points out, the distribution of the various kinds of igneous rock points to some magmatic differentiation in the intruded mass, in the sense that it is more silicic and salic near the center and more femic toward the borders. This is a mode of differentiational arrangement which is commonly met with, and which is so well known as not to call for the citation of corroborative examples here.

The available chemical evidence bears out this suggestion, in that the few analyses that have been made of the Washington igneous rocks show serial relations between them, indicating a community of origin. A very brief statement of this topic must suffice here.

The serial and comagmatic relations are shown most succinctly by the symbols denoting the positions of the various rocks in the quantitative classification, which, it is assumed, are intelligible to the reader. The analysis of the fresh Broad Branch granite given by Merrill is included The series of rocks and symbols is given in table 5

Inspection of these symbols shows clearly the gradual and progressive change in all the most essential chemical characters. As regards the relation of salic to femic molecules, the highly silicic binary granites are well within persalane, the less silicic biotite granites are all on the border between persalane and dosalane, and the diorites are in dosalane and salfemane. The amount of excess silica, shown in the ordinal positions, remains almost constantly quardofelic. There is a steady and almost uniformly regular decrease in alkalies as compared with salic lime as we go down the list, and a concomitant decrease in potash and increase in soda.

The same story is told by plotting the analytical data in the usual

[12] U. S. Geol. Survey Bull. 591: 47 (E and F).

way, using the molecular numbers as ordinates and the molecular silica percentages as abscissas; or still more clearly, by plotting the relative percentages of the basic oxides (alumina to potash) taken together against the silica percentages The graphs for each constituent thus obtained show very regular decreases or increases, quite in accordance with such observations as have been made on rock series from other regions. The points thus indicated furnish curves that need scarcely any "smoothing out," with the exceptions of certain data for the Rodman Street granite and the Rock Creek Tunnel hornblende diorite, some of the figures for which fall quite markedly outside the smooth curves given by the others, indicating that they are aberrant for some reason, such as possibly assimilation of intruded gneiss.

SUMMARY

The igneous rocks of the District of Columbia are intruded into Archean gneisses. Granites are most abundant, with small amounts of diorite, gabbro, and pyroxenite.

There are two types of granite. biotite granite (which seems to be the more common), and muscovite-biotite granite Both contain small amounts of oligoclase, but they differ chemically as well as regards the kind of mica present, the biotite granite being lower in silica and higher in lime. Transition forms probably occur. The biotite granite has silica percentages from 67 5 to 69.0 while that of the binary granite is about 72. Both types have undergone pressure, giving rise to more or less well marked foliated textures, although no very decided difference in chemical composition seems to be associated with the foliation. Epidote is developed in the more intensely crushed portions of the biotite granite, and this mineral is apparently wholly secondary in origin. Epidote is very rare or absent in the binary granite. No allanite, hornblende, or pyroxene was observed in the Washington granites.

TABLE 5 IGNEOUS ROCKS OF WASHINGTON, D. C, ARRANGED IN CHEMICAL SERIES

Name	Locality	Analysis and map reference	SiO_2	Symbol
Binary granite	River Road	(5)	71 92	I''.4 (1)2 3
Binary granite	Rodman Street	(6)	71 66	I'' (3)4 ''2 3
Biotite granite	Broad Branch	(3)	69 33	(I)II (3)4 3 3(4)
Biotite granite	Newark Street	(2)	69 19	I(II) 4 (2)3 3(4)
Biotite granite	Tilden Street	(1)	67 46	(I)II 4 ''3 3(4)
Biotite diorite	Georgetown		56 41	II'' 4'' ''4 4
Hornblende diorite	Rock Creek Tunnel		56 18	''III 4 4 4

The igneous rocks of the District have been but little studied, but there is reason to believe that the igneous complex is more femic toward the borders through magmatic differentiation. The analyses indicate a close comagmatic relationship between the various rocks. Further study of the igneous rocks of the District is very desirable.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Geology of the igneous rocks of Essex County, Massachusetts.* CHARLES H. CLAPP. U. S. Geol. Survey Bull. 704. Pp. 132. 1921.

Essex County is the northeasternmost county of Massachusetts. The special area whose geology is more particularly discussed in this bulletin lies almost wholly in the southern part of the county. Geologically the area is well known, chiefly because of its alkaline igneous rocks, among which are the types essexite and bostonite. Besides presenting local problems the area illustrates certain general features of the geology of igneous rocks, the more important of which are: (1) The sequence of the volcanic, batholithic, and dike phases of an igneous cycle. (2) The differentiation of two contrasted groups of rocks, the sub-alkaline, or calci-alkalic, and the alkaline. (3) The origin of shatter breccias along molar contacts of batholiths and the slope of molar contacts. (4) The contact assimilation of country rock by invading igneous magmas, forming hybrid rocks. (5) The formation of diabase dikes contemporaneously with irruptions of alkaline granitic rocks.

The writer throws light on some of the broader principles of the geology of igneous rocks, notably the formation of hybrid rocks by contact brecciation and assimilation and by impregnation of invaded rocks, and the differentiation of subalkaline magmas. The report discusses in detail the lithologic character, alteration, contact and structural relations of the considerable variety of igneous rocks found in the region. R. W. STONE.

GEOLOGY.—*Permian salt deposits of the south-central United States.* N. H. DARTON. U. S. Geol. Survey Bull. 715-M. Pp. 19 (205 to 223), pl. 1 (21), figs. 10 1921.

The bulletin presents a review of knowledge about the area of underground salt in eastern New Mexico, the Panhandle of Texas, and adjacent parts of Oklahoma and Kansas A map shows the probable approximate extent of the area which is at least 650 miles long and 150 to 250 miles wide. Information about the salt beds is derived from drilling for oil, gas, and water, but the difficulty of recognizing salt when penetrated in the ordinary methods of drilling is pointed out. The salt succession undoubtedly occurs in the Permian beds known as the Manzano group in New Mexico and the Marian formation in Kansas associated with red beds, gypsum, anhydrite, dolomite, and limestone. The salt is not a continuous body, but probably composed of separate lenses and the sections in which it occurs in different places are not comparable in detail.

The deposit lies in a wide synclinal basin with minor folds. The thickest salt is approximately at the bottom of the basin. This basin may there-

fore have existed at the time the salt was deposited. The greatest thickness reported is 700 feet. Thicknesses of 200 to 400 feet are not uncommon. For several years commercial deposits of potash salts have been sought in this salt mass but so far without success. Verbal records and graphic logs of the principal wells penetrating the salt in this area are given for each State involved. The author believes that the salt was formed by the evaporation of sea water in shallow basins with occasional deeper marine submergences indicated by beds of [marine?] limestone.

MARCUS I. GOLDMAN.

GEOGRAPHY and HYDROLOGY.—*Routes to desert watering places in the Salton Sea region, California.* JOHN S. BROWN. U. S. Geol. Survey Water-Supply Paper 490-A. Pp. 86, pls. 7, figs. 2. 1920.

This is the first of a series of detailed guidebooks on watering places in the desert region of the United States that is being prepared by the U. S. Geological Survey as authorized by Congress. The text comprises a brief description of the Salton Sea region—about 10,000 square miles in extent—practical suggestions to travelers, detailed logs of all desert roads with special reference to water supplies, and a list of watering places with brief descriptions. There is also a preface by O. E. MEINZER, which outlines the desert region of the United States (about 500,000 square miles in extent) and describes the scope and methods of the watering-place survey. The maps include a general map of the desert region of the United States and detailed relief maps of the Salton Sea region showing roads and watering places. The relief shading is by JOHN H. RENSHAWE. O. E. M.

PALEONTOLOGY.—Orthaulax, *a Tertiary guide fossil.* C. WYTHE COOKE. U. S. Geol. Survey Prof. Paper 129-B. Pp. 15 (23–37), pls. 4 (2–5). 1921.

Had this paper been written even so late as five years ago, it might well have been entitled, "*Orthaulax*, a guide fossil of the Middle Oligocene." The more conservative caption is necessitated by recent discoveries in Santo

Known stratigraphic occurrence of Orthaulax

Age.		Southeastern United States.	Dominican Republic	Porto Rico and Jamaica.	Leeward Islands.	Cuba.	Panama.
Miocene	Upper	Yorktown and Duplin formations.	[illegible] formation				
	Middle	St. Marys formation.[a] Choptank formation.[a] Calvert formation.[a]	Mao clay. Mao Adentro limestone. Gurabo formation.	Bowden marl		La Cruz marl	Gatun formation.
	Lower	Shoal River marl member. Oak Grove marl member. Chipola marl member. *O. gabbi.*	Cercado formation. Baitoa formation. *O. inornatus.*			Marl at Baracoa.	
Oligocene	Upper	Tampa formation. *O. pugnax.* *O. inornatus.*	Cevicos limestone. *O. aguadillensis.*	Aguadilla limestone *O. aguadillensis.*	Anguilla formation and limestone in St. Croix *O. aguadillensis*	Limestone at [illegible] (position doubtful). *O. [illegible]*	Emperador limestone *O. gabbi.* *O. gabbi.*
	Middle	Chert beds on Flint River, Ga. *O. pugnax.*	Tabera formation.		Antigua formation. *O. pugnax.*		Culebra formation.
	Lower	Vicksburg group.					

[a] [illegible] according to T. W. Vaughan, [illegible]

Domingo and by the downward trend of the arbitrary line dividing the Miocene from the Oligocene. The article is concerned with the value of *Orthaulax* as a *leit* fossil, the biological peculiarities of the genus, the historical development of the knowledge about it, the distribution of the known species and the systematic treatment of the five forms referred to it.

Orthaulax is unique among the gastropods in that the entire spire is encased in a shelly envelope, a modification of the outer lip analogous to the finger growths and flanges upon the closely related stromb, the common conch of the West Indies. As in most highly specialized groups, the term of life is short, and, even with the increased knowledge, the limits of distribution remain comparatively narrow. The tabular occurrence of the genus indicates its importance stratigraphically.

The systematic treatment is remarkable for the refinement of method employed. The determination of the species is based finally upon the sectioning of the specimens, though the characteristics are, as a rule, sufficiently distinct to justify a confident field determination.

JULIA GARDNER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

153D MEETING

The 153d meeting of the ACADEMY was held jointly with the Chemical Society of Washington in the assembly hall of the Cosmos Club, the evening of Thursday, January 20, 1921. The retiring President of the Academy, DR. C. L. ALSBERG, Chief of the Bureau of Chemistry, U. S. Department of Agriculture, delivered an address entitled *The relation of chemical structure to physiological action*. This has subsequently been published in the JOURNAL of the ACADEMY.[1]

154TH MEETING

The 154th meeting of the ACADEMY was held at the Cosmos Club, the evening of Thursday, February 17, 1921 Dr L. O. HOWARD, Chief of the Bureau of Entomology, U. S. Department of Agriculture, delivered an illustrated lecture entitled, *How the Government is fighting insects*. He discussed briefly the work of the Bureau over which he has presided for the last 27 years and with which he has been connected for more than 40 years, and traced the extraordinary growth of the service, which has been due to the increasing realization of the monetary importance of remedial work against insects affecting crops, the health of man and animals, stored food, and so on. From a beginning with one entomologist and an assistant, the Bureau has grown to a large organization with a budget of nearly two million dollars, with field laboratories scattered all over the country to the number of 75 or more, and with a corps of trained expert assistants numbering several hundreds.

Lantern slides were shown of the operations being carried on at a number of these stations against some of the principal crop pests, and the lecture closed with a moving picture film showing the latest discoveries in the fight against the cotton boll weevil.

In the course of his talk the speaker emphasized the point that the greater part of the work carried on in the Bureau is of the highest scientific character, requiring men of intensive training.

[1] This JOURNAL 11: 321–341 August 19, 1921.

155TH MEETING

The 155th meeting of the ACADEMY was held at the Cosmos Club, the evening of Thursday, March 17, 1921. Dr. A. McL. NICOLSON, research engineer of the Western Electric Company, Inc., New York, delivered an address on *The piezo-electric effect in certain crystals* The address was illustrated with lantern slides, and demonstrations were given of some of the practical applications of the crystals to the transmission and reception of sound.

156TH MEETING

The 156th meeting of the ACADEMY was held jointly with the Biological Society of Washington at the Cosmos Club, the evening of Saturday, April 2, 1921. Dr. A. D. HOPKINS of the Bureau of Entomology, U. S. Department of Agriculture, delivered an address entitled *Intercontinental problems in natural and artificial distribution of plants and animals.* In condensed form this has since been published in two papers in the Journal of the Academy: (1) *Intercontinental problems in bioclimatics; with special reference to natural and artificial distribution of plants and animals.*[2] (2) *Bioclimatic zones of the continents, with proposed designations and classification.*[3]

157TH MEETING

The 157th meeting of the Academy was held at the Cosmos Club the evening of Thursday, April 21, 1921. Dr C. G. ABBOT, Assistant Secretary of the Smithsonian Institution, delivered an address on *The solar constant observing stations of the Smithsonian Institution.*

In the course of his lecture the speaker described the studies of solar radiation carried out at Washington, D. C.; Bassour, Algeria; Hump Mountain, North Carolina, Mount Harqua Hala, Arizona, Mount Wilson, California, Calama, Chile, Montezuma, Chile; and Mount Whitney, California, at altitudes ranging from sea level to 14,500 feet. He summarized results accomplished in perfecting processes of investigation, in the invention and construction of highly precise standardized instruments, and in the securing of simultaneous determinations of the solar constant of radiation at Washington, Mount Wilson, and Mount Whitney, and the bearing of these results, notably with respect to meteorological investigations. The data are brought together in a paper of 20 printed pages, entitled *Studying the sun's heat on mountain peaks in desert lands*, which will appear shortly in the Appendix to the Report of the Smithsonian Institution for 1920.

WILLIAM R. MAXON, *Recording Secretary.*

BOTANICAL SOCIETY

150TH MEETING

The 150th regular meeting of the Botanical Society of Washington was held in the Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, March 1, 1921. 112 members and guests were present. Among the visitors were Dr. ROBERT F. GRIGGS of Ohio, Prof. LEO E. Melchers of Kansas, Dr A G. JOHNSON of Wisconsin, Mr. PAUL SIGGERS, about to leave for his new work with Johnston and Carleton in Panama, and Mr. C. VALLEJO, Agricultural Attaché of the Argentine Republic. In the absence of President CHAMBLISS, the meeting was called to order by Vice-President P. L. RICKER.

[2] This JOURNAL 11: 223–227 1921

[3] This JOURNAL 11: 227–229 1921

A preliminary report was made by Dr. A. S. HITCHCOCK on the question of providing Russian men of science with scientific literature.

Regular Program

HAVEN METCALF: *The story of a plant introduction.* (Address of the retiring President, illustrated with lantern slides.)

Because of various diseases and other factors, rice culture in the South Atlantic States was on the decline in the early nineteen hundreds. One rice disease in South Carolina called "blast" or "rotten-neck" was very serious. In order to study the disease further, Dr. and Mrs. Metcalf took a trip to Italy and found that the "Brusone" was the same as blast in South Carolina. Resistant rices were secured and introduced into the United States. They did not retain their resistance, but one of them, now known as Colusa, by still further selection, has become the second in production in California, producing in 1919 1,655,000 bushels of grain, with an estimated farm value of over four million dollars. (A fuller discussion of Dr. Metcalf's address will be published elsewhere.)

ROY G. PIERCE, *Recording Secretary.*

151ST MEETING

The 151st regular meeting of the Society was held in the Assembly Hall of the Cosmos Club at 8:00 p.m. Tuesday, April 5, 1921. 51 members and guests were present. President CHARLES E. CHAMBLISS presided. Mr. SOREN SORENSON and Mr. D. RUDOLF KURAZ were elected to membership. Mr. P. L. RICKER reported on the work of the committee on the preservation of the Shaw water lily garden. A contribution from the Botanical Society toward the printing of a pamphlet and map in furtherance of the project was requested, and was authorized. Mr. RICKER announced a series of "hikes" conducted by the Wild Flower Preservation Society and invited the members to join them.

Regular Program

W. H. WESTON. *Following a fungus through the Philippines.*

This lecture was illustrated with lantern slides exhibiting various phases of the botany of the islands, particularly the terraced rice fields, the tropical jungles, and the conditions surrounding the development and spread of the downy mildew of maize.

All but one of the known species of the downy mildews of corn occur in the Orient. No conception of the terrifically destructive effect of this disease can be gained from comparison with any disease known in America. Whole fields are destroyed. The disease is carried through the season by the production of enormous numbers of conidia. *Saccharum spontaneum*, wild grass, *Miscanthus japonicus*, and a primitive type of cultivated sugar cane growing in the remote interior of Northern Luzon were also found to be hosts of this disease. Maize of flinty, poor yielding, tropical types was found to be grown under widely varying conditions, ranging from the swampy soil and coral sand of the hot, humid coast, to the precipitous rocky slopes of high elevations in the cooler mountainous interior. Waxy maize, hitherto known only from China and Burma, was collected from two widely separated localities. On all these types the mildew was, under favorable conditions, almost equally destructive, its ravages, which were aided greatly by the

primitive agricultural practices of the people, being largely instrumental in bringing about such serious local food shortages as that which recently caused great hardship in Bohol.

J. F. CLEVENGER: *Zamia* integrifolia *Chapm., and its starch, Florida arrowroot.* (Illustrated with lantern slides).

Zamia integrifolia Chapm. is a small plant with a crown of leaves characteristic of the Cycadaceae, to which family this plant belongs. It has an enlarged tuberous-like stem which grows below the level of the ground. It is of interest that numerous prominent root tubercles occur on the roots of this plant. It is restricted to a limited region in the vicinity of Miami, Florida. It has not been found very far south of Miami and not much north of Dania, Florida, nor in regions which are liable to overflow.

Gifford reports "that in its raw state the leaves, seed and stems are undoubtedly poisonous." He further states "that animals which drink the red water from washing the starch usually die of slow poisoning." There are no available statements relative to the nature of this poison.

The starch has been prepared by the Seminole Indians and natives of South Florida by rather crude mills. The starch thus obtained constitutes an important source of food. For some time there existed in southern Florida two mills of comparatively large capacity, one at Dania and one at Little River. At the present time only the mill at Little River is engaged in the manufacturing of this starch.

The method for the preparation of this starch consists in grinding the rhizomes in the undried condition, mixing the ground material thus obtained with water, and subsequently running it over a fine screen. The starch is thus separated from the main portion of the fibrous material. This starchy material is then conveyed to settling tanks where the starch becomes further purified by a sedimentation process. This starch is subsequently dried and ready for the market.

It is believed to have been used by the natives who preceded the Seminoles, as a source of food. It supplied the early settlers with food, and to some extent, at least, enters into the arrowroot biscuit of commerce. It is interesting to point out that the people frequently dig up these rhizomes, soak them in water, and subsequently use them for fertilizer. The plant has been used as a pot plant, by transplanting.

Judging from the rapidly diminishing areas over which this plant grows, the apparent improbability of growing the plant profitably on new areas, and the long periods of waiting before the rhizomes from any given region may be subsequently dug up with profit, it is improbable that the starch will ever have anything more than a limited use.

The paper of Mr. ARNO VIEHOEVER was postponed to the 152d regular meeting. R. KENT BEATTIE, *Acting Secretary.*

SCIENTIFIC NOTES AND NEWS

The Section of Vertebrate Paleontology of the U. S. National Museum has recently received as a gift from the John A. Savage Company of Crosby, Minnesota, an extensive collection of bones of an extinct buffalo, named *Bison occidentalis* some years ago by Dr. F A. LUCAS. These remains were discovered in Pleistocene deposits which overlie a body of iron ore at the Sagamore Mine near Riverton, Minnesota. It has been comparatively easy to select a complete composite skeleton, which it is proposed to mount for the exhibition collection.

Secretary of Agriculture WALLACE has appointed a committee of six scientists from the Department to consider the problem of land utilization The committee consists of Messrs. L. C. GRAY of the Office of Farm Management and Farm Economics, C. V. PIPER of the Bureau of Plant Industry, G. M. ROMMEL of the Bureau of Animal Industry, C. F. MARBUT of the Bureau of Soils, E. E. CARTER of the Forest Service, and S. H. MCCORY of the Bureau of Public Roads.

The Bureau of Standards announces that in testing a number of imported sets of analytical weights it has been found that the weights from 500 to 50 mg. were made of a decidedly magnetic material. This property caused them to behave very irregularly under test. Such weights can readily be detected with a small hand magnet, and it would be well for purchasers of analytical weights to be on their guard against them, as under some circumstances serious errors might be introduced thereby.

Dr. C. G ABBOT of the Astrophysical Observatory sailed from New York on October 26 for Antofagasta, Chile, to inspect the solar radiation station at Mt. Montezuma. He expects to return in January.

Dr. L. H. DUDLEY BUXTON, anthropologist, visited the scientific institutions of Washington in October, on his way around the world on the Kahn traveling fellowship from Oxford University, England.

Dr IMMANUEL FRIEDLÄNDER, Director of the Volcanological Institute of Naples, visited the Geophysical Laboratory and the U. S. Geological Survey in October.

Mr. JAMES E. IVES has resigned as research associate and lecturer in physics at Clark University to become physicist in the office of industrial hygiene and sanitation of the Public Health Service in Washington.

Dr. WILLIAM C. KENDALL, scientific assistant and ichthyologist of the U. S. Bureau of Fisheries, has resigned after 33 years of service with the Bureau, to accept the position of ichthyologist in the Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry, Syracuse, New York.

Mr. GEORGE M. ROMMEL, chief of the animal husbandry division of the Bureau of Animal Industry, U. S. Department of Agriculture, has resigned to become editor-in-chief of the American International Publishers, New York City. Mr. Rommel had been with the Department since 1901, and had been chief of his division since its organization in 1910.

Dr. RALPH W. G. WYCKOFF, of the Geophysical Laboratory, Carnegie Institution of Washington, is on a year's leave of absence, which he will spend at the California Institute of Technology at Pasadena, California.

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GEOCHEMISTRY —*Note on the water of Borax Lake*[1] ROGER C WELLS U S Geological Survey

Borax Lake is of interest being the first locality in the United States at which borax was produced commercially It is a broad shallow lake seldom over a few feet deep situated east of the narrow arm of Clear Lake in Lake County California It has been described by J A Veatch J D Whitney C F Becker J A Philipps and others[2]

Borax was first noted in the water by J A Veatch in 1856 and shortly afterwards a bed of borax crystals was found in the mud in the bottom of the lake which was worked for borax by means of movable coffer dams The water of the lake in September 1863 contained 41 1 grams of solids to the liter according to an analysis by G E Moore quoted by Whitney and of this about 4 8 grams is anhydrous borax Melville s elaborate analysis published in Becker s monograph on the quicksilver deposits of the Pacific slope shows total solids of about 76 6 of which 5 grams per liter is borax (This sample was probably collected in 1887)

In August 1921 Hoyt S Gale collected a sample of water from the lake and very kindly forwarded it to the writer for study with the suggestion that a comparison of the present borax content with previous determinations would be interesting The material thus presented was welcomed as being also suitable for the study of the alkalinity and hydrogen ion concentration the latter being a physical property of alkali lake waters that has not yet been widely studied

The total solids obtained on evaporation and drying at 180° C amounted to 32 0 grams per liter The water is therefore now more dilute than the early samples mentioned above This is perhaps not

[1] Published by permission of the Director of the United States Geological Survey Received October 21 1921

[2] For references see bibliography by H S GALE U S Geol Survey Mineral Resources 1913 Pt II p 523

surprising as it is said that in 1861 the lake dried up entirely. The proportions of the principal salts appear to have changed somewhat since 1863 as shown by the following percentages:

	NaCl	Na_2CO_3	$Na_2B_4O_7$
1863	50	25	12
1887	53	40	6 6
1921	60	33	7 3

The figures for 1863 give the approximate composition stated by Whitney from Moore's analysis.[3] The statement is incomplete and the borax determination is open to question, but may be of the right order. The figures for 1887 and 1921 are calculated from Cl, total CO_2, and B_2O_3 and are therefore somewhat arbitrary inasmuch as bicarbonates and metaborates are neglected. The latter are evaluated as shown below. Since 1887 there appears to have been a slight gain in borax and sodium chloride and a loss in sodium carbonate. In the 1921 sample the Cl found was 11.6, SO_4, 0.05; Ca, 0.06; Mg, 0.07; CO_3, 4.90; B_2O_3, 1.62; K, 0.56 grams per liter. The titration alkalinity to methyl orange was 0.214 normal.

The alkaline character of the water may be expressed through the hydrogen ion concentration as $p_H = 9.75$. This measurement was made electrometrically, as described elsewhere.[4] The water is actually somewhat more alkaline than the Searles lake brine (for which $p_H =$ 9.48) although it is far less concentrated in total salts. This peculiarity is caused by the large salt effect in Searles brine.

In order to represent the dissolved alkaline matter in the form of the customary buffer salts, as has been done for Searles brine,[5] an artificial water, containing 18.5 g. sodium chloride, 0.5 g. magnesium chloride, 1 0 g. potassium chloride, and 0.03 g. calcium sulfate per liter was made up as a medium to which buffer salts could be added and the resulting p_H values determined A set of p_H determinations was then made with various proportions of sodium carbonate and bicarbonate, keeping the total CO_2 equal to that found in the lake water. Another similar set was made with mixtures of borax and sodium metaborate keeping the total B_2O_3 the same as found in the lake water. The results are given in table 1 and plotted in figure 1.

[3] Calif. Geol. Surv. 1: 98

[4] Journ. Amer. Chem Soc. 42: 2160. 1920. For general directions, CLARK, *The determination of hydrogen ions*

[5] Journ. Eng Chem 13: 691 1921.

The curves shown in the figure are drawn to pass through the observational data and also approximately parallel to the curves for the corresponding buffer mixtures in pure water.[6] The effect

TABLE 1

RESULTS OF p_H DETERMINATIONS MADE AFTER ADDING CARBONATE AND BORATE BUFFERS TO AN ARTIFICIAL LAKE WATER. TOTAL CO_2 = 4 26 G. PER LITER. TOTAL B_2O_3 = 1.62 G PER LITER

Percentage total CO_2 present as Na_2CO_3	p_H	Percentage of total B_2O_3 present as $Na_2B_2O_4$	p_H
20	9 07	50	9 42
50	9 63	70	9 74
75	10 10	80	9 95
95	10 78	90	10 27

of the salt in Borax Lake water seems to be about 45 and 75 per cent of that in Searles Lake brine in decreasing the p_H values for the car-

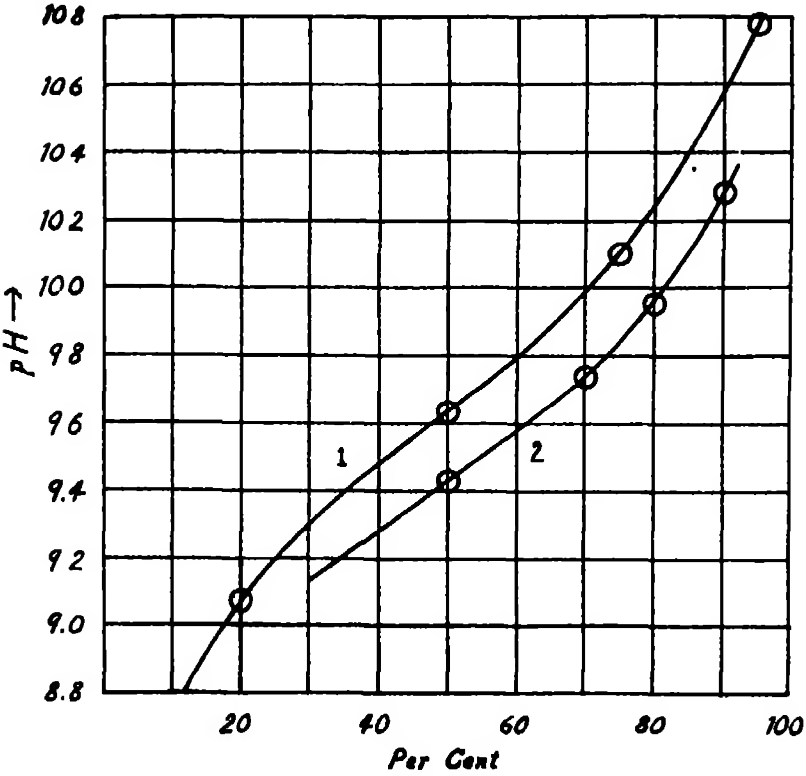

Fig. 1. p_H for mixtures of $NaHCO_3$ and Na_2CO_3, and of $Na_2B_4O_7$ and $Na_2B_2O_4$ in an artificial brine resembling Borax Lake water. Curve 1: per cent of total CO_2 present as Na_2CO_3 (balance $NaHCO_3$). Curve 2: per cent total B_2O_3 present as $Na_2B_2O_4$ (balance $Na_2B_4O_7$).

[6] Data given in PRIDEAUX, *The theory and use of indicators*, pp. 279 and 299.

bonate and borate buffers, respectively. The addition of salt makes the buffer solutions more acid. Until more measurements on the salt effect are obtained each case must be studied by itself, although it is evident that the salt effect increases only slowly with increasing concentrations of salt.

From the curves it is easily seen that in order to yield the value $p_H = 9.75$ the CO_2 and B_2O_3 should be distributed as follows in the respective salts:

$$CO_2 \begin{cases} 57 \text{ per cent as } Na_2CO_3 \\ 43 \text{ per cent as } NaHCO_3 \end{cases} \qquad B_2O_3 \begin{cases} 71 \text{ per cent as } Na_2B_2O_4 \\ 29 \text{ per cent as } Na_2B_4O_7 \end{cases}$$

or, as grams per liter:

Na_2CO_3	5 9	$Na_2B_2O_4$	2 17
$NaHCO_3$	3 5	$Na_2B_4O_7$	68

It is concluded that the proportions last given approximately represent the concentrations of the salts that determine the alkalinity of the water of Borax Lake. One factor that is not allowed for is the salt effect of the carbonate buffers on the borate buffers, and vice versa, but this effect is probably small compared with the salt effect of the sodium chloride present which has been allowed for. By a strange coincidence the percentage of total B_2O_3 present as borax is the same as that found for Searles Lake, but the percentage of CO_2 present as carbonate is 57, compared with 78 for Searles Lake.

Below (Table 2) is given a statement of the analysis deduced from the present investigation, in the form of gram ions per liter, with a similar one of Searles Lake brine for comparison. The minor constituents noted by Melville were not determined.

TABLE 2

ANALYSES DEDUCED FROM THE PRESENT INVESTIGATION IN THE FORM OF GRAM IONS PER LITER

	Borax Lake	Searles Lake
Ca	06	.
Mg	07	
Na (diff.)	11 42	143 7
K	56	31 9
Cl	11 60	159 2
SO_4	05	61 0
HCO_3	2 54	7.2
CO_3	3 34	25 4
B_4O_7	.52	4 3
B_2O_4	1.42	11 8
	31.58	444.5

Borax crystals remain in the mud of Borax Lake although the water is not now saturated with borax. It is not unusual to find certain crystallized salts in the bottom mud of a lake containing water that is not saturated with those salts. Water from the bottom mud and lower is also frequently more concentrated than the lake water. Such relations have been noted in the Wyoming lakes carrying sodium sulfate, in the Nebraska lakes carrying potassium salts, and in the Great Salt Lake, where Glauber's salt has been found below sand and clay. The explanation probably is that in the coldest or driest weather crystals are deposited and fall to the bottom where they become covered with silt and clay. The reverse process of solution, being chiefly dependent on diffusion, is too slow to occur in the alternate warm or wet seasons or even in several such seasons. Certain salt deposits may therefore owe their origin in some cases to extreme or unusual conditions rather than to average conditions, provided they become silted over.

PETROLOGY.—*Obsidian from Copan and Chichen Itza.*[1] HENRY S. WASHINGTON, Geophysical Laboratory, Carnegie Institution of Washington

OBSIDIAN FROM COPAN

In 1920, during his study of the Maya ruins at Copan, Honduras, Dr Sylvanus G. Morley obtained a number of obsidian cores, that is, the remnants of rock nodules from which knives and other implements had been flaked off by the ancient Maya. Dr. Morley very kindly gave these cores to me for examination, a courtesy for which I would express my thanks. It appears that many such cores are found by the natives among the ruins and along the valley floor, and that nodules of obsidian are said to occur in the tuffs of the neighborhood. As such cores, valueless in Copan, would scarcely be articles of trade, it may be safely assumed that the obsidian of those studied comes from the vicinity of Copan.

Little is known of the volcanic rocks of Central America. Obsidian, dacite, andesite, and basalt are mentioned and described briefly by the few petrologists who have dealt with the subject, but (except for the rocks of Panama and the Canal Zone) there are only five analyses of Central American rocks, and only one of these is of an obsidian.

The cores are from 10 to 13 cm. long, and from 2.5 to 3 cm. at the greatest thickness. They are roughly spindle-shaped (Fig. 1), with the greatest width near the middle in some of them, but near one end in

[1] Received November 4, 1921.

others. The ends are not sharply pointed, but are broken cleanly across. The cores are bounded laterally by 8 to 10 curved, narrow faces, produced by the perfect conchoidal fracture of the material, and nearly all these faces extend the whole length of the core. These narrow faces are slightly concave across their width.

The obsidian is of a uniform, jet-black color, perfectly vitreous, and with perfect conchoidal fracture. There are no streaks, and no phenocrysts are visible. In splinters the glass is brownish and very transparent. The thin section shows a clear colorless glass, homogeneous and with little or no evidence of flow. There are no bubbles but some very minute microlites are scattered sparsely through the glass; the larger (0.01 mm.) being irregular crystal fragments of pyroxene, and the smaller (0.001 mm.) opaque grains of magnetite. Their total percentage cannot amount to more than about 0.01 of the rock.

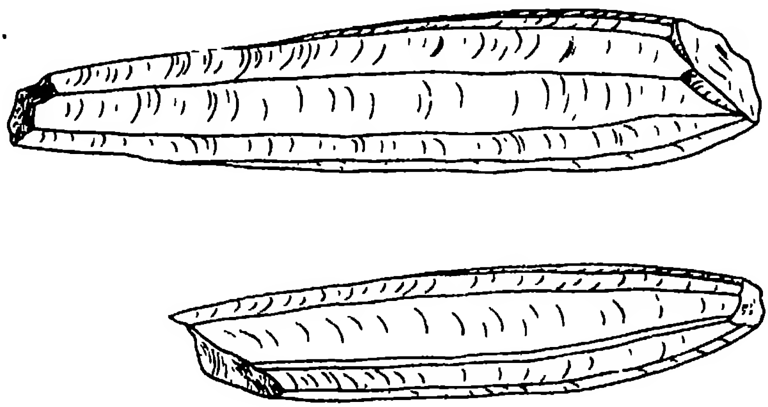

Fig. 1. Obsidian Cores from Copan

Dr. H. E. Merwin very kindly determined the refractive indices, these being measured on a specially ground prism. They are as follows: n_C = 1 4896, n_D = 1.4920, n_F = 1.4976, and n_G' = 1.5022. It will be seen that the value for yellow light (D) is slightly higher than the indices (determined by Merwin) of the obsidians of Lipari (Rocche Rosse = 1.488–9, Forgia Vecchia = 1.490), Monte Arci (1.487–9), and Milos (1.490).[2] The first three have about the same percentage of silica as the Copan obsidian, but are slightly more potassic and with less lime; while that of Monte Arci is higher in silica by about 2 per cent, with a little less soda, but about the same

[2] H. S. Washington. Amer. Journ. Sci. 50: 462. 1920.

percentages of potash and lime. These observations are in conformity with the general rule, that silica and alkalies tend to lower, and lime tends to raise, the refractive indices of obsidians.

The specific gravity, determined with the balance on a piece weighing about 31 grams, is 2.372 at 23.2°C., giving a density of 2 366.

TABLE 1

ANALYSES OF OBSIDIAN

	(1)	(2)	(3)	(4)
SiO_2	74 46	76 68	75 23	75 64
Al_2O_3	13 13	14 49	12 36	12 68
Fe_2O_3	0 49	n d	0 96	1 07
FeO	1 03	1 09	1 24	n d
MgO	0 29	0 84	0 01	trace
CaO	1 25	1 53	1 00	0 83
Na_2O	4 52	3 92	4 00	4 98
K_2O	4 37	1 20	4 62	3 51
H_2O+	0 10	0 36	0 73	1 58
H_2O-	0 03			
TiO_2	0 45	n d	n d	n d
P_2O_5	0 09	n d	0 27	n d
MnO	0 05	trace	n d	n d
	100 26	100 11	100 42	100 20

(1) Obsidian, Copan, Honduras WASHINGTON analyst

(2) Obsidian, Corinto, Nicaragua. J PETERSEN analyst J PETERSEN. Neues Jahrb. 1898: II, 157

(3) Obsidian, Cerro de los Navajos, Mexico F. BAERWALD analyst C A TENNE. Zeitschr deutsch. geol. Ges 37: 616. 1885

(4) Obsidian, Cerro de los Navajos, Mexico F. BAERWALD analyst C A. TENNE. *Loc. cit*

Chemical analysis gave the results shown in No. 1 of table 1, analyses of obsidians from Nicaragua and Mexico being given for comparison. In chemical composition the Copan obsidian closely resembles many others from widely separated localities, as may be seen by reference to U. S. Geological Survey, Professional Paper 99, pages 113 to 151. Its norm is as follows, represented by the symbol I.4. 1 (2).3(4).

Quartz	28 86	Diopside	2 75
Orthoclase	26 13	Magnetite	0 70
Albite	38 25	Ilmenite	0 91
Anorthite	2 22	Apatite	0 30

The Corinto (Nicaragua) obsidian, which is the only other Central American obsidian of which we have an analysis, is higher in silica and with lower alkalies, the soda greatly dominating over potash. One of the analyses of the Mexican obsidian is like that of Copan, but none of the analyses cited can be regarded as quite satisfactory

It is probable, however, that the Copan obsidian is much like the general run of Central American and Mexican obsidians, if we may judge from analogy with similar regions in the western United States and along the Andes, a comagmatic zone to which the volcanic rocks of Mexico and Central America belong.

OBSIDIAN FROM CHICHEN ITZA

Among a large accumulation of sacrificial offerings (mostly of jade) found some years ago in a *cenote*, or natural well, at the ancient Maya city of Chichen Itza in Yucatan,[3] were a few beads of obsidian.

The beads are cylindrical, from 2 to 5 cm. long and about 5 mm. thick, with a shallow groove running spirally around them from end to end The smooth but unpolished surface is brownish black, with irregular streaks of scarlet, which appear to be painted or burnt into the surface, as the color does not extend into the material below. They are apparently intended to simulate similarly mottled obsidians, which are fairly common, but discussion of this question of technique will be taken up elsewhere.

The obsidian is of a somewhat peculiar hair-brown color, quite different from the more usual brown of the Copan obsidian, but is colorless in thin section. It contains some bubbles, which vary in length from 0.02 to 0 10 mm. These are mostly spindle- or pear-shaped, the former frequently with one end drawn out to a sharp point. The bubbles are arranged in streaks, evidence of flow texture. Apart from these bubbles, the glass is perfectly clear and contains no microlites or phenocrysts.

Dr. Merwin determined the refractive index of this obsidian by the immersion method, and I would express my thanks to him for his kindness in making this and the other determinations on the Copan obsidian. He found the value $n_D = 1.489 \pm 0.001$. This is notably lower than the refractive index of the Copan obsidian, but is about the same as the indices for the Lipari and Milos obsidians. It is in accord with the rather high silica and alkalies and low lime and alumina.

The density was not determined, because the small amount of material available and the presence of the bubbles would have made the determination of little value.

[3] This collection, now in the Peabody Museum in Cambridge, Massachusetts, is to be described under the editorship of Prof. A. M Tozzer, to whom I am much indebted for the privilege of studying the stone objects and publishing the present description, which deals only with the petrological aspects of the obsidian

TABLE 2

Analyses of Pantellerite Obsidian and Cognate Rocks

	(1)	(2)	(3)	(4)
SiO_2	75 88	72 21	70 14	74 09
Al_2O_3	9 67	9 72	8 61	10 88
Fe_2O_3	2 23	3 26	6 01	3 35
FeO	0 83	1 07	2 73	0 42
MgO	0 21	0 29	0 20	0 30
CaO	0 72	0 82	0 45	0 16
Na_2O	5 13	4 42	5 44	4 56
K_2O	4 56	4 98	4 20	4 45
H_2O+	0 38	1 96	0 35	1 52
H_2O-		0 24	0 17	
TiO_2	0 10	0 62	0 86	n d
ZrO_2	n d	n d	0 14	n d
P_2O_5	n d	0 10	0 12	n d
SO_3	n d	n d	0 06	n d
MnO	trace	0 05	0 38	n d
	99 71	99 74	99 86	99 73

(1) Obsidian bead, Chichen Itza, Yucatan WASHINGTON analyst

(2) Comendite, Cuddia Nera, Pantelleria WASHINGTON analyst H S WASHINGTON Jour Geol 21: 697. 1913

(3) Pantellerite, Monte San Elmo, Pantelleria WASHINGTON analyst H S WASHINGTON *Op cit*, p 703

(4) Comendite, San Pietro, Sardinia A JOHNSEN analyst A JOHNSEN Abh preuss Akad. Wiss 1912: 22

A chemical analysis, incomplete because of paucity of material, gave the results shown in No. 1 of table 2. In the figures for silica, magnesia, and the alkalies, it is much like the analysis of the Copan and other common obsidians, but is somewhat lower in lime and titanium. In its low alumina and rather high ferric oxide (especially as compared with ferrous oxide), however, it differs widely from most obsidians, and shows close analogies with the more silicic pantellerites and comendites, as may be seen by comparison with the other analyses given in the table.

The alumina is, indeed, so low that there is a notable excess of soda and potash over the total amounts of alumina and ferric oxide, so that the norm contains, not only considerable acmite, but some of the sodium metasilicate molecule.

The close analogy of the Chichen Itza obsidian with the peculiar rocks of the Italian volcanoes will be evident, and the obsidian may properly be called a hyalo-pantellerite, the glass of which is also brown. The occurrence of such a lava within the area from which the votive offerings may be supposed to have come is an unexpected one. Lavas

TABLE 3

NORMS OF PANTELLERITE OBSIDIAN AND COGNATE ROCKS

	(1)	(2)	(3)	(4)
Quartz	35.34	31.14	27 60	31.32
Orthoclase	27.24	29 47	25 02	26.69
Albite	24 10	22 01	20 44	30 92
Acmite	6 47	9 24	17.56	6 93
Sodium metasilicate	2 68	1 10	1.34	none
Diopside	3.10	2 57	1.21	0 65
Hypersthene	0 23	0.46	4.10	0 50
Magnetite	none	none	none	1 39
Ilmenite	0 15	1 22	1 67	none
Apatite	none	0 34	0 34	none

(1) Obsidian, Chichen Itza. (I) II. 3''.1.3.
(2) Comendite, Pantelleria. (I) II (3) 4 1.3.
(3) Pantellerite, Pantelleria. II 3(4) 1.3.
(4) Comendite, Sardinia. I (II). (3) 4.1 3.

of these types are rather rare and are invariably connected with characteristically sodic comagmatic regions. We know of no such sodic region in or near Central America or in southern Mexico, the nearest being the locality of nephelite syenite, in the State of Tamaulipas,[4] in northeastern Mexico. The lavas here, however, are apparently dacite, andesite, and basalt, Finlay mentioning no highly sodic lavas, such as phonolite or pantellerite. There are occurrences of pantellerite and other sodic lavas in western Texas, and I have pointed out elsewhere the probable existence of a zone of sporadic occurrences of sodic rocks along the eastern border of the North American continent, and that it probably continues down along the east coast of South America.

As has been said above, we know very little of the volcanic rocks of Central America, or of Mexico, for that matter, so it is quite possible that another isolated district of sodic rocks occurs in southern Mexico or northern Central America. The finding of these beads made of pantellerite obsidian in the Chichen Itza *cenote* gives warrant for this belief, which is further strengthened by the abundance of jade objects found in this general region, the material of which may be considered of Mexican or Central American provenance.

It would seem to be clear, from the descriptions above, that the Chichen Itza obsidian is derived from a volcanic source quite distinct and, we may reasonably suppose, far distant from that of the Copan cores. The occurrence of two such widely different obsidians, one of which belongs to a chemically very peculiar kind of rock, serves

[4] G. I. FINLAY. Ann. N. Y. Acad. Sci. 14: 247. 1904.

to emphasize the desirability, for archaeological as well as for petrological reasons, of a better knowledge of the volcanic rocks of Central America and Mexico.

ENTOMOLOGY.—*On the Orthopterous group Phaneropterae (= Scudderiae), with descriptions of a new genus and species.*[1] A. N. CAUDELL, Bureau of Entomology.

The genus *Phaneroptera* was erected by Serville in 1831,[2] with two originally included species, *Locusta lilifolia* Fabr., and *Locusta curvicauda* DeGeer. The only designation of genotype for this genus, so far as now known to the writer, was by Kirby in 1906,[3] when the *Gryllus falcatus* of Poda was so indicated. In his treatment of this matter Kirby followed Brunner in considering the *Locusta lilifolia* included by Serville as being a misdetermination, the real species being presumably the *Gryllus falcatus* of Poda. But, when an author names a particular species as originally included in a genus that species is presumed to be correctly determined, the sane and only rational reasoning applying, it seems, as in the case of genera based wholly on a misdetermined species, and covered by opinion No 65 of the International Code of Nomenclature and by paragraph No. 96 of the Entomological Code. Thus the Fabrician *lilifolia* included by Serville in his genus is not to be considered a misidentification, and is eligible for genotype citation. The designation by Kirby of the non-included species *falcatus* being invalid the genus *Phaneroptera* is therefore as yet without a designated genotype, and one of the two originally included species, *lilifolia* and *curvicauda*, must be selected as the type. The first of these species, *Locusta lilifolia* Fabr., is the genotype of the monobasic genus *Tylopsis* of Fieber, 1858. The second species, *Locusta curvicauda* DeGeer, is the type of the genus *Scudderia* of Stal 1873, by original definite designation and by virtue of being the sole species of that monobasic genus. Now paragraph 98a and 101 of the Entomological Code and opinion 6 of the International Code restrict one to the selection of *curvicauda* as genotype, which I hereby do by definitely designating *Locusta curvicauda* DeGeer as the genotype of the genus *Phaneroptera* of Serville. This selection, being in accord with both recent codes governing such matters, can scarcely fail to meet with the approval of most nomenclatorialists.

[1] Received October 21, 1921.

[2] Ann. Sci. Nat. 22: 158.

[3] Syn. Cat. Orth. 2: 434.

From the above it is clear that Stal's genus *Scudderia* must fall as a synonym of *Phaneroptera* Serville, having the same genotype and being more recent by almost two decades. This leaves the species listed under *Phaneroptera* by Kirby[4] (except *attenuata* Walk., *marginalis* Brunn., and *annulata* Brunn., as noted below) without valid generic assignment. For these species and *grandis*, *nakoensis* and *tympanalis* M. &. S., I propose the new generic name *Anerota*, with *Gryllus falcatus* Poda as the designated genotype.
The synonymy is as follows:

Anerota Caudell, nom nov.

Phaneroptera Brunner (not Serville), Monogr. Phaneropt. 23, 209. 1878

Phaneroptera Kirby (not Serville), Syn. Cat. Orth. 2: 424. 1906.

The writer sincerely regrets these changes, the sinking of an old and well-known American genus and the introduction of a new generic name to replace an older one. However, such acts, being based on sound nomenclatorial grounds, are necessary if we attempt to comply with codified rules. And, as therein lies our only hope for an ultimately stable nomenclature, the sooner such changes are wrought the better

The type of *Phaneroptera attenuata* Walker is in the British Museum, where it was studied by the writer in 1913 It is a female in poor condition, the abdomen being missing and the rest of the insect glued on a card. Most of the parts used in classification were, however, well preserved and prove that the species was wrongly placed by Walker and Kirby. It has conchate foramina and belongs to the genus *Tylopsis*, where it is a synonym of the older species *T. bilineolata* Serville. *Phaneroptera marginalis* Brunn. was described from an imperfect female, the anterior and intermediate legs being wanting. Kirby assumed the character of the missing parts to be the same as in Walker's *attenuata* and so synonymized it under that species. It seems probable that in this Kirby was correct, and the synonymy is as follows:

TYLOPSIS BILINEOLARIS Serville, Orth., p 419. 1839.

Phaneroptera attenuata Walker, Cat. Derm. Salt. Brit. Mus. 2:338. 1869.

-*Phaneroptera marginalis* Brunner, Monogr. Phaneropt. 210, 214. 1878.

[4] Syn Cat. Orth. 2: 434–437 and 3: 574.

Phaneroptera annulata Brunn. has been made the type of the genus *Xenodoxus* of Carl, described in 1914, thus eliminating it from other generic assignment.

Inscudderia, genus nov.

This is a member of the group Phaneropterae (= Scudderiae), but tends towards the Insarae, standing between the genera *Phaneroptera* (= *Scudderia*) and *Insara*, hence the generic name *Inscudderia*. Superficially it resembles *Insara*, especially *I. elegans*, but structurally it seems more like *Phaneroptera*, though in this respect also it tends towards the Insarae, especially in the narrow tegmina with their slightly concave caudal margins, two or more branched radial sectors and variegated color, and the longer and more slender legs. The greatly prolonged and non-style bearing subgenital plate of the male, the fastigium of the vertex failing to meet that of the face, the slightly spinose genicular lobes and the non-sellate pronotum exclude it from the Insarae. In the group Phaneropterae (= Scudderiae) this genus runs out in Brunner's keys, Monogr. Phaneropt , to *Scudderia* on page 16 except that the fore and middle femora are slightly toothed ventrally, which is also often true of the anterior femora of *Scudderia*, or *Phaneroptera*, as we have above shown this American genus must now be called But there are various characters for the ready separation of this new genus from that older one, the more prominent ones being the twice or more branched radial sector, the more slender and posteriorly slightly concave tegmina, the comparatively longer and more slender legs, the more rounded lateral carinae of the pronotum with the posteriorly flattened disk of the same, the ventrally subspinose intermediate femora and the more decidely armed ventral margins of the posterior femora.

Description —(♂, the ♀ unknown). Head with the fastigium of the vertex very narrow, not exceeding a fourth the width of the basal segment of the antenna, subhorizontal and failing to meet the frontal fastigium, the presenting face rounded, eyes almost round, prominent Pronotum rounding into the lateral lobes without distinct lateral carinae except in the posterior fourth, where the disk, which is otherwise gently convex, is wholly and conspicuously flattened, and there the lateral carinae are sharp and distinct; lateral lobes about equally high as long, the humeral notch deep.

Organs of flight fully developed; wings hyaline with the tips, which project beyond the closed tegmina a distance approximately equal

to the pronotal length, green, especially in the costal area where it is coriaceous like the tegmina; tegmina narrow, slightly over five times as long as broad, at the widest point being very slightly broader than the pronotal length, the posterior margin barely concave; first radial branch two or three forked and joined near the base to the ulnar vein by a diagonal cross vein. Legs slender, the posterior femora just reaching the tips of the closed tegmina; spine of anterior coxa long and sharp; anterior tibiae with open foramen on each face; all the tibiae sulcate dorsally and armed on both ventral margins with several black spines of moderate size; above the intermediate and posterior tibiae also bear sharp black spines on both margins, only one to three on the cephalic margin of the middle ones, and on that margin there is no apical spine, as there is on the opposite margin and on both margins of the hind tibiae; anterior tibiae wholly unarmed on the dorso-cephalic margin, the opposite margin with a basal spine (often very small) near the lower margin of the foramen, a terminal spine and from one to three additional ones at irregular intervals between the above; posterior femora armed beneath on both margins with several black triangular teeth, the fore and middle ones with from none to two very minute teeth on the caudal margin beneath and the anterior ones may have one or two exceedingly minute teeth on the ventro-cephalic margin; posterior genicular lobes very briefly but acutely pointed, the others rounded.

Abdomen with the segments evenly truncate except the terminal one, which is slightly prolonged and apically broadly notched, as shown in figure 1, *c;* subgenital plate greatly prolonged and upcurved, as in *Phaneroptera* (= *Scudderia*), without apical styles but the latero-apical angles roundly tubercular, the apex notched; supraanal plate elongate-triangular, deeply concave above; cerci heavy, about twice as long as the last dorsal segment of the abdomen, subcylindrical, tapering moderately to about the middle and then again growing stouter to the noticeably swollen apex, where there is a heavy, sharply pointed and inwardly directed tooth about a third as long as the body of the cercus. (See fig. 1, *b* and *c*.)

Type *Inscudderia taxodii*, sp. nov.

Inscudderia taxodii, sp. nov.

This is undoubtedly one of the most distinct species of Orthoptera, and that such a striking katydid inhabiting the southeastern United States should so long escape notice is indeed remarkable.

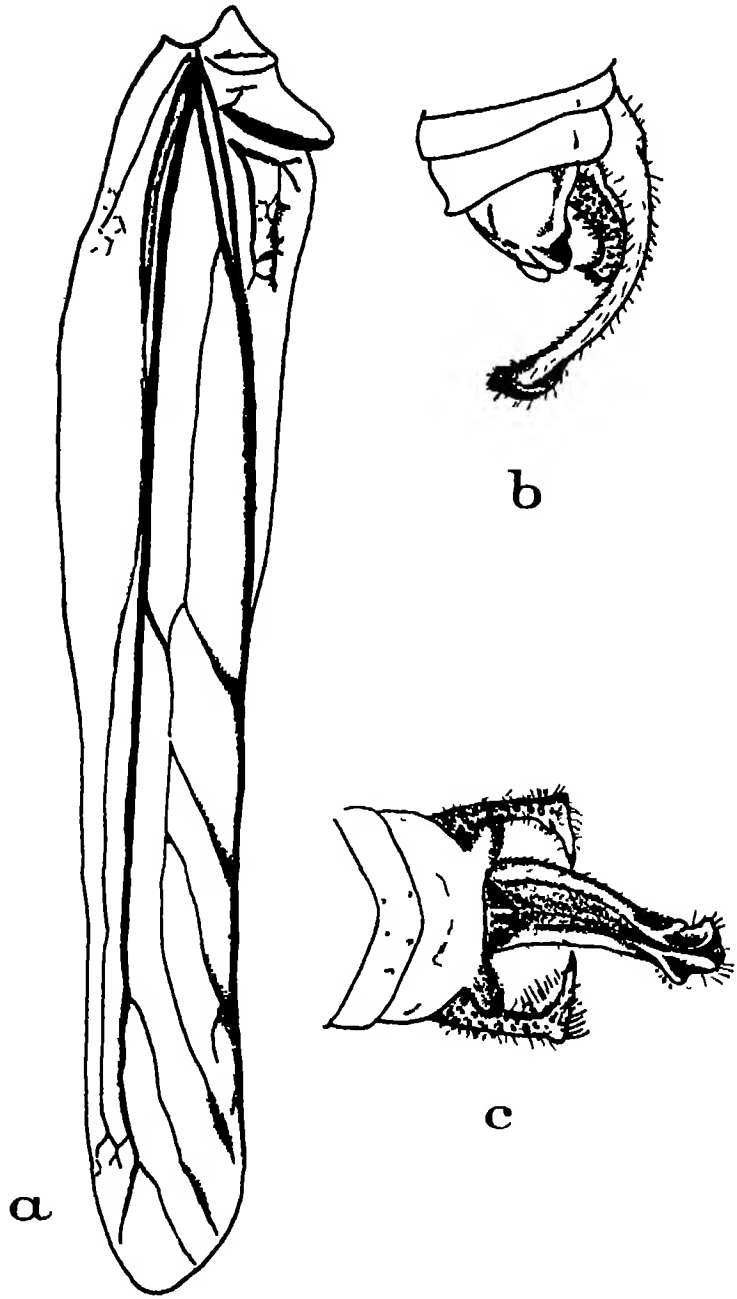

Fig. 1. *a*, Left tegmen of type; *b*, end of abdomen, lateral view; *c*, end of abdomen, dorsal view. Figures by Dr. A. BOWING.

Description.—(♂, the ♀ unknown). Head slightly broader than the pronotum; labial palpi slender, the terminal segment cylindrical, slightly and gradually thickening apically, the tip truncate, the whole three times as long as the preceding one, which in turn is about one-half as long as the penultimate segment; eyes yellowish brown, the rest of the head yellowish green, the slender antennae being darker green with some very narrow black bands scattered along the length. Pronotum green with a narrow longitudinal mesial stripe on the disk and with the cites of the lateral carinae somewhat lighter; pronotal disk truncate anteriorly, posteriorly broadly and uniformly rounded; lateral lobes with the humeral sinus rounded and margined with black, the callous large but indistinct; there is a small black splotch anterior of the center of each lateral lobe and there are two small transverse black spots on the posterior margin of the pronotal disk, the mesial longitudinal stripe separating them. Legs as noted in generic description, the posterior femora shaped as in *Insara;* foramina of fore tibiae shining black. Wings slender, over twice as long as broad, the posterior apical margin evenly curved, the membrane transparent with green venation, the apex green and thickened as noted in the generic diagnosis. Tegmina green with the radius, the anal vein, which continues to near the tip of the tegmina, and the heavier of the stridulating veins of the singing area piceous and a series of several conspicuous short, pointed, diagonal, basally directed piceous streaks extending from the posterior margin, following the veins as shown in fig 1, *a;* these black veins anddiagonal markings show very conspicuously against the greent egmina, imparting to them a very characteristic appearance Abdomen moderately heavy; last dorsal segment about twice as long as the preceding one and apically very broadly notched and laterally concave, the lateral angles thus formed appearing as rounded tubercular-like protuberances, as shown in figure 1, *c*, supraanal plate twice as long as the basal width, the sides straight and tapering to a narrowly rounded apex, the entire dorsal surface deeply concave; subgenital plate very like that of *Phaneroptera* (= *Scudderia*), being a narrow elongate, upcurved flattened plate with conspicuously thickened margins, concave above, convex beneath and the apex triangularly notched, the terminal lateral lobes rounded and about as long as thick, but scarcely at all style-like; cerci characteristic in shape, as shown in the accompanying figure, figure. 1.

The immature form shows little essential difference from the adult except that the colors show evidence of the same brilliantly hued

variegation as exhibited by some of our species of *Phaneroptera*, though the second segment of the antenna does not show such conspicuous enlargement as is present in the young of some species of the latter genus. The legs are dotted with black and the posterior femora have some larger black markings on the upper surface and on the outer face; the abdomen is ornamented with numerous short narrow red dashes, the lateral lobes of the pronotum are centrally reddish with yellowish lower margin and with some black markings. The pronotal disk of the nymphs, at least the only two examined, does not show the absolute flattening of the posterior fourth as is so conspicuously true of the adult form.

Measurements of adult.—Length, pronotum, 4 mm , tegmina, 21 mm.; posterior femora, 20 mm. Width, tegmina at widest point, 4 mm ; pronotum across the posterior flattened portion, 2 3 mm.

Type, ♂, Durant, Miss , July 15, 1921. C. J. Drake, collector; paratypes, one adult ♂ and two immature ♂♂, one nearly full grown and one about half grown, Pickens, Miss., July 16, 1921, taken by the same collector.

Type and paratypes in collection of the United States National Museum.

Catalog No. 24952, U S N. M

In addition to the above four specimens Prof. Drake distinctly recalls having seen specimens, adults and nymphs, at the following localities in Mississippi: Fulton, Columbus, Vicksburg, Natchez and Port Gibson. Not realizing their interest and importance he unfortunately kept but the above described specimens, though many, he says, might easily have been secured.

Prof. Drake, who is to be congratulated on the discovery of this unusually interesting addition to our native orthopterous fauna, found this beautiful little katydid to occur quite common on cypress, where he often took them while beating the foliage of that tree for Hemiptera. He also on one occasion swept a few adults from weeds and grass in the immediate vicinity of cypress. The adults aroused his interest by the nicety with which their colors blended with those of the host plant.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Contact-metamorphic tungsten deposits of the United States.* FRANK L. HESS and ESPER S. LARSEN. U. S. Geol. Surv. Bull. **725-D.** Pp. 65(245–309). 1921.

Contact-metamorphic tungsten deposits have been formed through the combined action of the heat and solutions emanating from a cooling intrusive granitic magma on limestones and the other intruded rocks and to a less extent on the invading granitic rock itself, by which the rocks are altered to or replaced by an aggregate of garnet, epidote, diopside, quartz, calcite, scheelite, and other minerals. Most deposits of this class are at or very near the contacts, and they clearly represent replacement of the limestones and other rocks. The tungsten mineral of such deposits is invariably scheelite.

Most of the known contact-metamorphic tungsten deposits in the United States are in the Great Basin region in California and Nevada and northwestern Utah, but Oregon, Arizona, and New Mexico are known to contain one deposit each, and it is probable that other such deposits will be found in widely different parts of the country.

The geologic features of contact-metamorphic deposits and the causes of metamorphism are discussed. Most of the paper is made up of a brief preliminary description of the contact-metamorphic scheelite deposits in the western United States. R. W. STONE.

GEOLOGY.—*Chrome ores in Pennsylvania, Maryland and North Carolina.* ELEANORA BLISS KNOPF and J VOLNEY LEWIS. U. S. Geol. Surv. Bull. **725-B.** Pp. 55 (85–139). 1921.

Chrome ore was discovered in Maryland as early as 1827. Until 1860 Maryland and Pennsylvania furnished the world's supply of chrome ore, but in 1860 the chief source of the world's supply was transferred to Turkey. Since 1882 practically all of the output of chrome ore in the United States has come from the Pacific coast, and the industry in the Eastern States has lain dormant.

The chromite is found in rock ore and in alluvial sand. The rock ore is both massive and granular. It occurs in serpentinized pyroxenites and peridotites that probably represent ultrafemic differentiates of a gabbro intrusion. The massive ore occurs in pockets of variable size. The ore occurs at intervals in a belt 50 miles long that extends from the southwest corner of Chester County, Pa., to the neighborhood of Baltimore, Md. It has probably originated by the sinking of chromite grains during the crystallization of a highly magnesian magma.

The chrome ores of North Carolina occur in granular olivine rocks (peridotites), which form numerous small isolated outcrops in a belt 5 to 25 miles wide throughout the mountainous western part of the State, a distance of 200 miles.

This report describes the character of the rocks and their hydration and decomposition products, also the character and classification of the chrome ores and the nature of the gangue minerals.

The chrome ores are believed to have been formed by the local concentration of suspended grains and crystals of chromite during the cooling of the molten peridotite magma after its intrusion into the gneisses. Convectional circulation was probably the chief agent in the process. The chance of large bodies of deeper-seated ore having been formed at the same time is thought to be very small. R. W. STONE.

BIOLOGY.—*A new classification of animals.* AUSTIN H. CLARK. Bulletin de l'Institut Océanographique (Monaco), No. 400, pp. 1–24. 20 September, 1921.

This paper is an amplification of the short note on the steps in the evolution of animals published in this JOURNAL,[1] and also includes a consideration of the corresponding steps in the evolution of plants A key is given to all of the animal phyla, in which the larger plant groups are also included, and finally there is a list of the phyla and higher groups accepted by the author. Several of the higher groups and one of the phyla (Calyssozoa) are here proposed for the first time. A. H. C.

ENTOMOLOGY.—*Dispersion of flies by flight* F. C. BISHOPP and E. W. LAAKE. Journ. Agric. Res. **221**: 729–766. 1921.

This paper discusses the dispersion of flies by flight and experiments listed and described show that under rural and urban conditions many species of flies have marked powers of diffusion. The house fly spread a maximum distance of 13.14 miles from the point of release. It is noted that the species tested often pass feeding and breeding grounds and from the experiments there are certain facts which indicate that they have marked migratory habits. The relation of the direction of dispersion and the direction of the winds is discussed and it is stated that no correlation could be determined because when the experiments were conducted the wind conditions were considered as choppy. The evidence gained by the experiments justifies the conclusion that passing vehicles on highways are not a dominating factor in the dispersion of the flies used. There is no marked difference between the dispersion of males and females. The facility with which flies travel many miles emphasizes the importance of the general application of sanitary measures looking toward the suppression of fly breeding. S. A ROHWER.

ORNITHOLOGY.—*A new ptarmigan from Mount Rainier.* W. P. TAYLOR. Condor **22**: 146–152. 1920.

A new ptarmigan from Mount Rainier is here named *Lagopus leucurus rainierensis*. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Waterfowl in Nebraska.* H. C. OBERHOLSER Bull. U. S. Dept. Agric. **794**: 2–35. 1920.

The principal waterfowl breeding ground in Nebraska is the sandhill region, which occupies the middle portion of the State. The most important groups of lakes are those of eastern Cherry County, Brown County, Garden and Morrill Counties, and those at the head of the North Loup River. All these

[1] This JOURNAL **11**: 207–208. May 4, 1921.

lakes are relatively small and shallow, and many are more or less ephemeral. The water in most is fresh, but in a few is alkaline.

Notes on habits, occurrence, and distribution of 56 species of water birds are here given, 42 of which are breeding species of the State, and 14 are only autumn transients. The most abundant breeding duck is *Querquedula discors*.

H. C. O.

ORNITHOLOGY.—*Observations on the habits of the white-winged dove.* ALEXANDER WETMORE. Condor 22: 140–146. 1920.

The habits of *Melopelia asiatica mearnsi* as observed near Arlington, along the Gila River in Maricopa County, Arizona, present some interesting features. The species were found breeding in colonies, some of them as large as 2000 pairs. The young are fed by regurgitation for three or four days, after which they are given fresh food They remain in the nest three or four weeks. A regular morning flight from the breeding colonies begins an hour after sunrise and continues until nearly noon of each day. The species feeds much on wheat and barley, but as most of this is waste grain, the damage to the cultivated crops of the region is comparatively slight.

H. C O.

ORNITHOLOGY.—*Observations on the habits of birds at Lake Burford, New Mexico* ALEXANDER WETMORE. Auk 37: 221–247, 393–412, pls. 1–7. 1920.

Lake Burford lies at an altitude of 7000 feet in the northwestern part of New Mexico. The observations here recorded relate to 105 species, and include sometimes extended notes on habits, particularly of the water birds.

H. C OBERHOLSER

ORNITHOLOGY.—*A peculiar feeding habit of grebes* ALEXANDER WETMORE. Condor 22: 18–20. 1920.

The stomachs of grebes usually contain a considerable quantity of feathers. These are eaten by the birds during the process of preening. Although these feathers are eventually ground up and enter the intestines, a plug of them remains in the pyloric lobe of the stomach, apparently serving as a strainer to prevent the passage of the more indigestible parts of food eaten.

H. C. OBERHOLSER.

ORNITHOLOGY.—*A new cliff swallow from Canada.* H. C. OBERHOLSER Canadian Field-Nat. 33: 95. 1920.

The form of *Petrochelidon albifrons* inhabiting most of western Canada is here described as *Petrochelidon albifrons hypopolia* It is the largest of the races of *Petrochelidon albifrons*, and inhabits northwestern North America, from Mackenzie and Alaska, south to Montana and Alberta, migrating through the western United States probably to South America. H. C. O.

ORNITHOLOGY.—*Description of a new clapper rail from Florida.* H. C. OBERHOLSER. Proc. Biol. Soc. Wash. 33: 33–34 1920.

A clapper rail from the Florida Key's is described as *Rallus longirostris helius*.

H. C. O.

ORNITHOLOGY.—*The migration of North American birds. XIII. European Starling and the Bobolink.* H. C. OBERHOLSER. Bird Lore 22: 213–216. 1920.

The European Starling (*Sturnus vulgaris vulgaris*), was introduced into the

United States about 1890. Since that time it has spread into Maine, central New York, Pennsylvania, West Virginia, and southeastern Virginia, where it now breeds. It has wandered also to Ohio, Alabama, and Georgia, and probably will continue to spread into suitable areas in the eastern United States. The well-known Bobolink (*Dolichonyx oryzivorus*), breeding in North America, migrates to winter in Bolivia and Argentina. Tables of dates of its spring and fall migration are here given. H. C. O.

ORNITHOLOGY.—*A synopsis of the races of the Guiana flycatcher,* Myiarchus ferox *(Gmelin).* H. C. OBERHOLSER. Proc. Indiana Acad. Sci. **1918:** 304–308. 1920.

Eight subspecies of this bird are here recognized, one of which has not heretofore been regarded as distinct. H. C. O.

ORNITHOLOGY.—*Description of a new* Otocoris *from California.* H. C. OBERHOLSER. Condor **22:** 34–35. 1920.

The breeding horned lark of the northern Sierra Nevada in California is here named *Octocoris alpestris sierrae.* H. C O

ORNITHOLOGY.—*Fifth annual list of proposed changes in the A. O. U. check-list of North American birds.* H. C. OBERHOLSER. Auk **37:** 274–285. 1920.

This list includes the changes in nomenclature and status of North American birds proposed during the calendar year 1919. It comprises the addition of 7 genera, 8 species, and 16 subspecies, together with 67 changes in generic, subgeneric, specific, and subspecific terms, involving altogether 90 names. Furthermore, there are 14 eliminations from the North American list as now understood, these consisting of 7 genera, 1 species, and 6 subspecies.

H. C. O.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

853D MEETING

The 853d meeting of the Philosophical Society of Washington was held in the Assembly Hall of the Cosmos Club October 8, 1921. It was called to order by President FARIS with 44 persons present.

The first paper of the evening, on *A furnace temperature regulator,* was presented by Mr. H. S. ROBERTS, 3D, and was illustrated. It was discussed by Messrs. PAWLING, WHITE, L. H. ADAMS, and others.

This paper was a description of a thermo-regulator for use with electric resistance furnaces and an account of its operation.

The apparatus is a modification of the regulator described by White and Adams in 1919, in which the heating coil of the furnace is placed in one arm of a Wheatstone bridge and the supply of energy to the furnace varied in a single step by means of a switch operated by the galvanometer of the bridge. In the White-Adams apparatus the switch was moved by a motor-driven mechanism and could only open or close at particular instants separated by arbitrarily fixed intervals of about one second. In the present regulator

the switch is operated by an electro-magnet as soon as a contact button on the boom of the galvanometer reaches one or the other of two fixed contact buttons. As the force with which the galvanometer presses the contact buttons together is very small, it is necessary to employ only a very small current through its contacts, in order to prevent their sticking. For this purpose a high resistance polarized relay is placed between the galvanometer contacts and the magnet that operates the main switch. As a further precaution, the secondary of a small transformer is connected in series with the coil of the galvanometer, while the primary is connected to the heating circuit in such a way that the operation of the main switch causes a ballistic deflection of the galvanometer towards its central position. All the appliances used are of standard make with a few simple changes.

The adjustment of the rate at which energy is supplied to the furnace is effected by varying the ratio of the time it is supplied at a higher rate to the time it is supplied at a lower rate. Thus the present type of galvanometer is able to secure the proper ratio in a single cycle while the type employed by White and Adams could, in general, only approximate it after several cycles by a fraction whose numerator and denominator were integers. Under certain conditions this caused a rather large, slow oscillation of the temperature of the furnace.

In order to vary the temperature of the furnace slowly for taking heating or cooling curves, one of the arms of the bridge is shunted by a variable rheostat whose resistance is changed in equal steps at intervals of 30 or 60 seconds. This arrangement has been found to give a steady change of temperature, which, however, is not quite linear.

The regulator, when used with the ordinary type of platinum resistance furnace, has been found to hold the temperatures up to 1250° constant within 0.2° C. for several hours, in spite of variations of 5° in the room temperature and of 6 per cent in the line voltage. At higher temperatures the temperature falls slowly, but may be maintained within 0 2° by an occasional manual adjustment. The temperature coefficient of nichrome or chromel wire is too low for the regulator; but nickel wire may be used up to perhaps 500° and some other alloy, such as alumel, may be found to work at still higher temperatures. As is the case with the White-Adams regulator, this apparatus, in its present form, is not suitable for use with alternating current or with the pulsating current furnished by the mercury arc rectifier.

The second paper, on *Aerial navigation*, was presented by Mr. H. N. Eaton, and was illustrated. It was discussed by Messrs. L. J. Briggs, Littlehales, A. F. Beal and Pawling.

Aerial navigation is a recent development as it is only since aircraft have become capable of flying for long distances that the necessity for navigating them as ocean-going vessels are navigated has arisen. Aerial navigation resembles marine navigation in general principles but is more difficult in application owing to the higher speeds of the craft and of the supporting medium, to the impossibility of charting the winds as the ocean currents are charted because of the variability of the former, and to the fact that freedom of motion in three dimensions introduces additional problems. Fortunately it is not necessary to determine position as accurately in the case of air-craft as in the case of ships on the ocean, since an error of from 10 to 20 miles involves only a few minutes additional flying time.

There are three general scientific methods of aerial navigation; dead reckon-

ing, astronomical observation, and directional wireless telegraphy. Dead reckoning involves the measurement of air speed, ground speed, heading, drift, and the amount and direction of the wind. The chief difficulty in this method of navigation arises from the fact that the motion of the craft over the ground is due to the resultant of the air velocity of the craft and the effect of the wind, the latter being often difficult to determine. Instruments have been developed to measure directly or indirectly all of these quantities.

In general principles marine and aerial navigation by astronomical observations are practically identical. The sextant is the universal instrument used for observation on the celestial bodies in both cases. In the air, however, it often happens that no horizon is available to furnish a reference line and it is then necessary to use an artificial horizon of some type, bubble, pendulum, or gyroscopic. Consequently, sextants with these horizons attached are commonly used in aerial navigation. It is worthy of notice that the aerial navigator often has available natural horizons which are never visible from the surface of the sea. The top surface of the haze lying over the ocean and flat layers of clouds often furnish excellent horizons.

The radio direction finder can be used in the air to determine the position of the craft by measuring the directions in which radio waves from the craft reach two or more fixed stations or radio waves from the fixed stations reach the craft.

H. H. KIMBALL, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

THE PUEBLO BONITO EXPLORATIONS

Mr. NEIL M. JUDD, curator of American archeology, U. S. National Museum, returned to Washington recently after having been occupied in New Mexico for more than five months as director of the National Geographic Society's Pueblo Bonito Expedition. Pueblo Bonito is one of the largest and best preserved prehistoric ruins north of Mexico. The Society has obtained a permit from the Department of the Interior and it is expected that the ruin can be wholly excavated within five years. No public notice has yet been issued as to the results of this first season's explorations but it is understood that the expedition was entirely successful both from the viewpoint of excavations actually completed and from the amount of data recovered.

A unique feature of this newest National Geographic Society expedition—one which has created considerable favorable comment among American men of science—is a proposed series of annual conferences at Pueblo Bonito to which specialists in the various humanistic sciences will be invited. The first of these symposiums, held last August, was attended by archeologists and agriculturists; geologists, botanists, and soil experts will be present at next year's meeting. The willing cooperation of these gentlemen—leaders in their respective fields of research—has made it possible to attack the problem presented by the marvelous ruins of Pueblo Bonito on a scale not thought possible heretofore; their combined efforts should result in a very distinctive contribution to the history of ancient America.

NOTES

The following lectures have been given recently in the Bureau of Standards Physics Club series on the physics of the Earth: Monday, October 31, WIL-

LIAM BOWIE: *The theory of isostasy;* Monday, November 7, HARRY FIELDING REID: *The causes of earthquakes;* Monday, November 14, LYMAN J. BRIGGS: *The measurement of the acceleration of gravity at sea.*

Captain ERNEST L. BENNETT, formerly in command of the battleship *New York*, has been designated by the Navy Department as director of the naval experimental and research laboratory now nearing completion at Belleview, on the Potomac River below Washington. Five buildings, including office and laboratory, machine shop, forge and foundry, pattern shop, and power plant, are under construction.

Dr. TORBJÖRN GAARDER, director of the biochemical laboratory of Bergens Museum, Bergen, Norway, visited the scientific institutions of Washington early in November.

The Directors of the American Chemical Society have elected Mr. H. E. HOWE, of the National Research Council, editor of the *Journal of Industrial and Engineering Chemistry* to succeed Dr. CHARLES H. HERTY, who has resigned to become president of the newly organized Association of Synthetic Organic Chemical Manufacturers

Dr. WILLIAM C. KENDALL, scientific assistant and ichthyologist of the U. S. Bureau of Fisheries, has resigned after nearly thirty-three years of service with the Bureau, to accept the position of ichthyologist in the Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry, Syracuse, New York.

The collection of birds of the late WILLIAM PALMER has been transferred from George Washington University to the Division of Birds, U. S. National Museum. This collection is noteworthy for the number of District of Columbia records and for the young and molting plumages it contains.

Dr. GUSTAV TROEDSSON, paleontologist at the University of Lund, Sweden, and now traveling on a fellowship in the United States, spent a part of October in studying the Cambrian and Ordovician collections in the National Museum.

Mr. S. L. WILLIS, formerly in charge of the preparation of ceramic data for the U. S. Tariff Commission, has resigned to accept a position with the Corning Glass Works of Corning, New York

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ZOOLOGY —*A key to the Philippine operculate land mollusks of the genus* Ceratopoma[1] PAUL BARTSCH, United States National Museum

In 1918 we published in this JOURNAL[2] a *Classification of the Philippine operculate land shells of the family Helicinidae, with a synopsis of the species and sub species of the genus Geophorus* In that paper we gave keys to the subgenera and species of the largest genus, namely, *Geophorus*, of the subfamily Helicinidae Since then enough material has come to hand to enable us to similarly treat another genus, namely that of *Ceratopoma*, a key to the species of which is herewith furnished (see page 502)

Ceratopoma has the operculum less specialized than any other Philippine Helicinid It consists of a simple horny shell without calcareous deposit The type of the genus is *Helicina caroli* Kobelt

The animal, like *Geophorus*, is usually a ground dweller and may be found among dead leaves as well as in crevices of rocks At the present time the genus is known from Luzon, Leyte, Siargao and northeastern Mindanao, and it is quite possible that careful collecting in the islands between the two extremes will reveal additional species

Ceratopoma caroli Kobelt comes from the island of Siargao It is a large species, with the parietal callus chestnut brown In fact, it is the only *Ceratopoma* so far known with a brown callus

Ceratopoma henningiana Möllendorff was described from Pena Blanca, Luzon, and differs from all the other *Ceratopomas* in having a broad brown basal band near the periphery

Ceratopoma cagayanica, sp nov, differs from the other two known large non color-banded *Ceratopomas* in having the peripheral keel limited on the base by an incised line, in which character it agrees with *Ceratopoma henningiana* Mollendorff The type, Cat No

[1] Published by permission of the Secretary of the Smithsonian Institution Received November 8 1921

[2] This JOURNAL 8 643–657 1918.

KEY TO THE PHILIPPINE SPECIES OF CERATOPOMA

Shell large, greater diameter more than 13 mm.
  Parietal callus chestnut brown . . . . *caroli* Kobelt
  Parietal callus not chestnut brown
    Peripheral keel limited on the base by an incised line
      Base with a brown peripheral band . . . . . *henningiana* Möllendorff
      Base without a brown peripheral band . . . . *cagayanica* Bartsch
    Peripheral keel not limited on the base by an incised line
      Umbilical callus about one-half of the diameter of the shell . . . *emaculata* Möllendorff
      Umbilical callus not one-half of the diameter of the shell
        Umbilical callus about one-fourth of the diameter of the shell . *emaculata cabaliana* Bartsch
Shell small, greater diameter less than 8 mm.
  Shell subglobose[1]
  Shell not subglobose
    Shell depressed conic
      Upper surface strongly spirally striated . . . . *contermina* (Semper) Kobelt
        Greater diameter 6 mm. . . . . *contermina contermina* (Semper) Kobelt
        Greater diameter 4.9 mm. . . . . *contermina iota* Bartsch
      Upper surface not strongly spirally striated
        Upper surface without spiral sculpture on the later whorls . . . . . *rosaliae* Pfeiffer
          Greater diameter 7.6 mm. . . . . *rosaliae rosaliae* Pfeiffer
          Greater diameter 6.7 mm. . . . . . *rosaliae manilana* Bartsch
          Greater diameter 5.7 mm. . . . . *rosaliae igorota* Bartsch

[1] The mollusk described by Wagner as *Ceratopoma contermina camiguinensis* from Camiguin, Luzon, should come near here, but I have not seen specimens of it, and therefore am unable properly to key it.

302763, U. S. N. M., comes from Cagayan, Mindanao. It has 4.5 whorls and measures: altitude, 7.5 mm.; diameter, 13.5 mm.

Two forms of *Ceratopoma* are known from the island of Leyte, one having the umbilical callus about half the diameter of the shell, which is *Ceratopoma emaculata* Möllendorff, the other having the umbilical callus only about one-fourth the diameter of the shell, which may be known as **Ceratopoma emaculata caballiana**, subsp. nov. The former we collected in the mountains south of Tacloban, Cat. No. 258771, U. S. N. M. The latter comes from Sitio Menoiho, Caballian, Leyte. The type is Cat. No. 302741, U. S. N. M.

The remaining members of the genus are all from the island of Luzon, and are small, none exceeding 8 mm. in diameter. Two of these have a subglobose outline, namely, *Ceratopoma quadrasi* Möllendorff, which comes from Caxiguran, and the shell described by Wagner as *Ceratopoma contermina camiguinensis* from Camiguin, Luzon. The latter I have not seen, and consequently have not placed in the key. The figure given by Wagner resembles that of *Ceratopoma quadrasi*, but from what we know of the distribution of *Helicinas* there seems little doubt that it is distinct, and if specimens were at hand characters could be given to key it.

The remaining forms are depressed-conic, and can be divided into two species, one having the upper surface strongly spirally striated. This is *Ceratopcma contermina* (Semper) Kobelt, which was described from Pancian, northern Luzon, and has a diameter of more than 6 mm., and a smaller race, which may be called **Ceratopoma contermina iota**, subsp. nov., from Cagayan, Luzon. The type of this, Cat. No. 302758, has $4^1/_8$ whorls and measures: altitude, 3.2 mm.; greater diameter, 5.6 mm. The other species, *Ceratopoma rosaliae* Pfeiffer, is without spiral striation on the upper surface. The typical form we have seen from the eastern side of Isabella and Nueva Viscaya Provinces, Luzon.

A smaller race occupies the Manila Bay region, to which we now give the name **Ceratopoma rosaliae manilana**, subsp. nov.. The type, Cat. No. 184924, U. S. N. M., comes from Manila. It has $4^1/_3$ postnuclear whorls and measures: altitude, 3.8 mm.; diameter 6.7 mm.

A still smaller race comes from the Benguet Province which we have called **Ceratopoma rosaliae igorota**, supsb. nov., the type of which has $4^1/_4$ whorls and measures: altitude, 3.2 mm., diameter, 5.7 mm.

ZOOLOGY.—Marionella (Eurystoma *Marion*, 1870); *an emendation, with notes on a new birefringent substance, marionellin, found in the intestinal cells.* (*Contributions to a science of Nematology,* XI)[1] N. A. COBB, U. S. Department of Agriculture.

The name *Eurystoma*, applied by Marion[2] in 1870 to a new genus of free living marine nemas discovered by him near Marseilles, France, was preempted, having been applied by Rafinesque in 1818 to a genus, of molluscs. Naturally, investigations, made during the last half century enable one, at the present time, to emend Marion's original description. Having examined as many more new, and as yet unpublished, species of the genus as have been already published, I venture to make this emendation, based on a study of about twenty-five species, and to propose for the genus the new name *Marionella*, in commemoration of its original author.

Marionella, nom. nov.

Eurystoma Marion, Ann. Sci. Nat. Zool. V. **13**: 19. 1870. Not *Eurystoma* Raf. 1818.

Cuticle and setae.—The thin layers of the transparent, colorless cuticle are traversed by transverse striae so exceedingly fine that they are very difficult to see even with highest powers of the microscope. Occasionally oblique striae also are to be seen in the cuticle of the lips, running in the direction of a left-handed screw. There are no lateral wings to the cuticle, and the striae are not altered on the lateral fields. There are no longitudinal striae in the cuticle itself, but the attachments of the somatic muscles give rise to longitudinal markings of a character somewhat resembling true striae. The contour of the body is always plain.

The cephalic setae, which are one-third to two-thirds as long as the lip-region is wide, are six or ten in number. Even when at first sight there appear to be only six, it is frequently found that in reality there are ten,—each of the four submedian setae having a very short and very inconspicuous companion hugging its base. The setae, two lateral and four or eight submedian, are usually slightly curved, of medium size to very slender, tapering, and somewhat acute, and have innervations that are most clearly visible near their bases; they are of medium stiffness to flexible, and spread outward from the lateral surface of the head opposite the apex of the onchium. Occasionally the larger setae *can be seen to be about three-jointed.* There are no special subcephalic setae. On the anterior portion of the neck in the vicinity of the head there are always to be found a few small, slender setae, one-sixth to one-eighth as long as the corresponding body diameter; these usually project at right angles to the neck or incline forward at an angle of sometimes as much as forty-five degrees. Not infrequently among the cervical setae there is one, a dorsal one, two to three times as far back as

[1] Received November 10, 1921.

[2] Ann. Sci. Nat. Zool. V. **13**: 19. 1870.

the base of the head, which is more prominent than the others. The somatic setae appear always to be reduced to innervations. There are no conspicuous pores on the surface of the body, but the ellipsoidal glandular cells of considerable size invariably found in the lateral fields are connected with the exterior by means of *very small and inconspicuous pores.*

Head and pharynx.—The somewhat rounded to subtruncate head is usually continuous with the neck, but is sometimes set off by a slight contraction, or by a very slight, broad, shallow constriction. The lip-region, on the other hand, is nearly always set off by a very slight, narrow and shallow, but usually distinctly visible constriction. The membranous lips are themselves thin and confluent, and apparently close by virtue of their elasticity. Their margins are very finely striated and possibly sometimes fimbriate. The lips are supplied externally with six forward-pointing papillae (or six sets of papillae), arranged in a single circlet having a diameter about one-half as great as that of the lip-region. These papillae are so exceedingly small as usually to escape observation. Their innervations are also exceedingly inconspicuous. Usually it is only when the papillae happen to project forward a little in exact profile that they come into view.

At first sight the pharynx appears to have the form of that of *Oncholaimus*. It is, however, nearly always *divided into two distinct chambers* of more or less equal length, the anterior of which is somewhat the wider and the more symmetrical. This regular anterior chamber is nearly always a napiform cavity one-half to two-thirds or even three-fourths as wide as the corresponding portion of the head. The posterior chamber is of smaller size, usually only about three-fourths as wide as the anterior chamber, and more or less irregularly spheroidal in form. The refractive walls of the pharynx are well-developed, but not very thick. The pharynx is usually armed with a single *well-developed, forward-pointing onchium*, but there may be one or two additional smaller onchia in exceptional cases. The apex of the main, and usually only, onchium, always occupying the right ventral submedian position, extends forward sometimes as far as the lips. The convex-conoid, enlarged base of the onchium fills the posterior chamber of the pharynx comparatively full. This enlarged portion of the onchium is continued in the front chamber by a narrower, more slowly tapering, convex-conoid, more or less acute summit. This organ is perforated and so serves as the *outlet of a large oesophageal gland.* The posterior pharyngeal chamber is separated from the anterior by a constriction, marked in its most pronounced form by the presence of narrow and refractive, transverse, arcuate elements or thickenings, placed end to end in a circle. Adjacent to this circle, usually in front of it and close together, there are one to three *transverse rows of denticles*, each consisting of either about thirty-two, or about sixty-four to eighty, somewhat forward-pointing units. These more or less inward pointing denticles are rather acute, cylindroid-conoid, uniform in size, and are usually so minute as to be barely resolvable with high powers of the microscope.

When viewed from in front, the pharynx is seen to be very nearly round. The margin of the lip-region is so thin and filmy that oftentimes it is difficult to delimit. An exact count of the denticles in a specimen of an unpublished but typical species, gave the following figures:—anterior series of denticles 62; second series 62; back series of larger denticles 20;—this decreased number in the back row being due not only to the fact that the denticles are larger

and farther apart, but also to fact the that one-third of the circumference is destitute of denticles, namely that part of the circumference opposite the large onchium. In this particular region, however, the interior walls of the pharynx are very finely longitudinally striated. The back row of denticles, it should be pointed out, is on the wall of the posterior half of the pharynx.

The neck is conoid, or occasionally subcylindroid, and ends in a cylindroid or, more often, a rather decidedly convex-conoid head.

Amphids and eye-spots.—Though the *amphids are well-developed*, they are rarely plainly to be seen. Their exterior expression consists of *two dorsally sub-lateral concavities* two to three times as wide as long, impinging on the bases of the lateral setae. Though the peripheries of the amphids may seem to be closed, they are, in fact, nearly always found to be open on the posterior margin near the lateral fields. As a rule their contours are almost invisible, so that their form and extent are mainly indicated by the apparent absence in them of the fine structural elements to be seen elsewhere in the cuticle of the head. When clearly defined, their contours are found to be reniform with the convex side forward. They are located on or near the base of the lip-region, and more or less opposite to the rows of denticles. They are usually one-third to two-fifths as wide as the corresponding diameter of the lip-region and two to three times as wide as long.

More often than not two eye-spots are present. These take the form of spheroidal, compact collections of about one hundred brownish granules, each collection lateral in position and lying between the oesophagus and body-wall,—being about one-fourth as wide as the corresponding portion of the neck, and removed from the anterior extremity by a distance two to four times as great as the width of the head. Anteriorly, these ocelli often present a spherical cavity in which there is at least the suggestion of a spherical lens.

Oesophagus.—The simple conoid oesophagus is destitute of bulbs and receives the base of the pharynx in its anterior extremity, where it is usually about half as wide as the base of the head. Near the nerve-ring it is usually about one-half, and posteriorly usually about three-fifths, as wide as the corresponding part of the neck. It is always separated from the intestine by a distinct cardiac collum about one-third as wide as the base of the neck. While not conspicuous, the lining of the oesophagus is a distinct feature throughout its length. Though the oesophageal musculature is usually fine, the structure is occasionally coarse in the posterior part. Rarely, yellowish spherical granules are found in the tissues of the oesophagus. The oesophageal glands are well-developed, or at least one of them is; as before stated, they empty into the pharynx through pores in the onchia. The right submedian gland is without exception the largest. There is usually a well-developed conoid or hemispherical cardia one-third to one-half as wide as the corresponding portion of the neck.

Intestine.—The intestine becomes at once one-half to two-thirds as wide as the body, and is made up of cells of such a size that few are required to build a circumference. Its walls are thick, and its lumen faint. Its cells invariably contain fine spherical granules of more or less variable size, the largest of them being one-fortieth to one-twentieth as wide as the body. The granules are scattered, or sometimes numerous, in the cells, and may be so arranged as to give rise to a faint tessellated effect, though this is unusual.

Doubly refractive granules (Marionellin) in the intestinal cells.—In the single layer of cells composing the intestine, an undescribed species of *Marionella* presented about twenty scattered special cells, more numerous and closer together anteriorly, each packed with doubly refractive granules (marionellin) mostly of very small size. Marionellin occurs in other species of *Marionella.*

These special intestinal cells were not distributed along a definite longitudinal line as in *Ironus*, where there is a decided dorso-ventral symmetry to the intestine due to the dorsal cells having a different character from the ventral. The interspaces between these special cells in this species of *Marionella* increased rather regularly from front to rear.

The discovery of these special intestinal cells is an additional observation *indicating differentiation among the cells of the nema intestine*. Such differentiated cells are now known to the writer in the following genera, among others: *Enoplus*, *Bathylaimus*, *Ironus*, *Mononchus*, *Eurystoma* (all carnivorous). It seems very reasonable to suppose that these differentiated cells may have functions similar to those of the glands accessory to the intestine of other and larger animals. Assuming that digestion in nemas has a general similarity to that of the higher animals, it would seem that gastric, hepatic, renal and other functions must exist in some form in the nema; thus far, however, very few of these functions can be assigned to special organs, as few or no such special organs exist. Instead of each cell of the intestine carrying out all of these distinct functions, in view of the above observations there is now morphological evidence of *"division of labor," and when these differentiated cells have been adequately investigated, we shall probably be able to assign to them definite functions*, and, for illustration, be able to apply to them some such terms as "hepatic cells," "renal cells," "spleenic cells," etc.

Tail.—The tail in *Marionella* takes on one of two distinct forms, according as there *is or is not a spinneret present*. If there is no spinneret the tail is conoid from the anus to the acute terminus, sometimes however tapering a little more rapidly in the anterior portion than elsewhere. In species possessing this form of tail, usually the tail of the male is the shorter, and the narrow conoid posterior part may appear rather as an appendage to the short but bulky anterior part. Most of the species, however, possess *three well-developed unicellular caudal glands* and a blunt, conoid, unarmed, and symmetrical terminal spinneret about one-fourth as wide as the base of the tail. If any setae occur on the tail, they are exceedingly small and very inconspicuous. The three quite separate ducts of the caudal glands are plainly visible in the tail and end posteriorly in three separate ampullae. The unicellular glands themselves are arranged in a loose tandem in front of the anus, the foremost being removed a distance from the anus several times as great as the corresponding body diameter.

Lateral fields: glandular cells.—The lateral fields are usually about half as wide as the body, and contain large, granular, ellipsoidal, *glandular cells* about one-third as wide as the body and emptying on the surface of the cuticle by means of exceedingly *minute pores*. These large glandular cells are situated from point to point throughout the length of the body, the distance between them being from one to four times as great as the width of the body

Renette.—The renette cell is invariably situated behind the neck and empties by means of a long, narrow, faintly visible duct. The narrow in-

conspicuous ampulla is situated nearly opposite the base of the pharynx. The obscure *excretory pore is invariably located in the lip-region* opposite the row of cephalic setae. The presence of the duct and ampulla usually causes the pharynx as well as the portion of the oesophagus near the head to be a little nearer to the dorsal side of the body than to the ventral.

Nerve-ring.—The nerve-ring is always a rather conspicuous feature. As a distinct collar it surrounds the oesophagus a trifle obliquely and is of medium size, and has arranged both in front of it and behind it numerous large nuclei, whose grouping, however, does not appear to be very orderly.

Female organs.—The female sexual organs are *invariably double and reflexed* ('f'). The vulva, though large, is more or less continuous and not very conspicuous. The well-developed vagina leads inward at right angles to the ventral surface about two-fifths of the way across the body, and, though fairly muscular, is not very amply cutinized.

The two straight uteri are of such a size as to contain two or more eggs at a time, arranged tandem; these latter are thin-shelled, smooth, usually ellipsoidal or somewhat elongated, and are deposited before segmentation begins. The reflexed ovaries are broad, or of medium width, taper more or less, and extend one-half to two-thirds the distance back to the vulva. The ova in them are arranged single file except near the blind end, where they are arranged irregularly.

Male organs.—The tail of the male is like that of the female except that it is usually shorter and more pronounced in its features, especially in species lacking a spinneret. In all the species that have been carefully examined in this respect, namely in the majority of the species, there are *two outstretched testes* extending in opposite directions, the anterior one ending a neck-length or more behind the cardia, the other near the beginning of the posterior fourth of the body. The two equal spicula are invariably arcuate, and occasionally strongly so. At their widest part they are one-sixth to one-eighth as wide as the corresponding portion of the body. They are from one and one-fourth to two times as long as the anal body diameter, and when viewed in profile their proximal ends appear to lie opposite to or slightly dorsad from the body axis,—very rarely ventrad. The proximal ends are almost always very slightly cephalated by expansion, but they are sometimes faintly cephalated by constriction or by contraction. They are somewhat slender, of rather uniform width, and rather blunt at the free end, where they sometimes terminate in a simple or denticulate crochet. The gubernaculum, placed at right angles to the distal parts in the spicula, though sometimes of uniform width, usually tapers internally to a blunt or acute point, which lies opposite to or dorsad from the body diameter. From this apophysis muscles lead fore and aft to the dorsal body wall. The portion of the gubernaculum applied to the spicula is one-sixth to one-eighth as long as these latter.

Supplementary organs.—Invariably *two large, ventral, pre-anal supplementary organs are present*, though in a few species they are more or less vestigial. They are placed in front of the anus in such fashion that the posterior one is about as far in front of the anus as the spinneret is behind it, and the anterior one about as far in front of the posterior as this latter is in front of the anus. There is, however, some variation in the situation of this pair of supplementary organs in the different species. Nearly always the posterior supplement is a little smaller than the anterior, some-

times markedly so. When well-developed, these organs consist of highly refractive elements, both external and internal, which are *very striking in their appearance*. To a considerable extent these supplements can be *protruded and withdrawn*. When protruded they are very prominent. When withdrawn they may leave the ventral contour comparatively even; and yet, even when withdrawn, they are hardly less conspicuous than when protruded, owing to their highly refractive character. The most striking internal elements are two in number to each supplement, extending, one forward and the other backward, and may *appropriately be termed "levers."* These levers are somewhat finger-shaped pieces of cutinized material that serve for the attachment of muscles. They usually taper but little, and their internal extremities are invariably blunt. The two levers of a given supplement are usually practically equal in size. When the supplement is at rest, the levers lie near the ventral side of the body and parallel to it. In such circumstances the exterior portion of the organ protrudes only slightly; but when the free inner ends of the levers are drawn inward so that they lie at an angle with the ventral surface, sometimes as great an angle as forty-five degrees, the external portions of the supplements are protruded. The external portion of each organ has the form of a laterally compressed cup, or trough, whose profile is exteriorly flat, or more often slightly concave, and interiorly more or less semi-circular. While the depth of the organ may sometimes equal its width, often it is less, and sometimes only one-half or one-third as great. Those species showing the maximum development of the supplementary organs present cases where the depth of the organ is one-fourth as great as the corresponding diameter of the body. In one species the supplementary organs are asymmetrical, the anterior lever or anchor having become vestigial, and the anterior portion of the cup or trough having diminished relatively in size, so that the contour of the longitudinal section of the organ is triangular rather than semicircular. By means of a duct each supplementary organ is *connected internally and forward with a large glandular cell*, as in *Bolbella*.

Setae on the male.—Just in front of the anus on the male there are usually to be found a few minute setae, either ventral or subventral in position. They are very short and very inconspicuous. There may be a single one at the anus; more often there are one or two subventral ones on each side Occasionally there are two rows extending to near the posterior supplement. These setae are arcuate, acute, and when two are present on each side of the anus, one of the pair is usually located immediately behind the other and is of smaller size. No other papillae or setae have been observed on the tail end of the male. There is no bursa.

Habitat.—The genus *Marionella* has hitherto been supposed to be of rather small size. It is in reality large, and is widespread in the various oceans. While the individuals of a given species may not be numerous, or very widespread, the number of specific forms observed is yearly augmenting. The two sexes are about equally common.

The genus is most nearly related structurally to *Bolbella*, *Symplocostoma*, *Thoönchus* and *Catalaimus*.

Marionella spectabilis (Marion) is still retained as the type species.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Geology of the Cement oil field, Caddo County, Oklahoma.* FRANK REEVES. U. S. Geol. Surv. Bull. 726-B. Pp. 45 (41–85). 1921.

It has long been believed that the region of tilted strata which borders the Wichita Mountains should contain local anticlines favorable for the accumulation of oil and gas. The pronounced anticline at Cement and anticlinal folds at Lawton and to the south in Cotton County support this belief. The production of oil at Cement proves not only that the structure at that locality is of the type favorable for oil accumulation but that there are adequate reservoir beds and a source of petroleum.

The area lies about 15 miles northeast of the Wichita Mountains, in the Permian "Red Beds" plain, which encircles the Wichita uplift and out of which the mountains rise "like islands in a sea."

The surface rocks of the Cement field and about 1,500 feet of the underlying beds are regarded by the writer as of Permian age. They consist of red and blue shales, red and gray sandstone, gypsum, and limestone.

The geologic structure is described and its relation to the accumulation of oil is discussed.

The oil produced so far in this field has come from a series of shales and sandstones, which underlies the surface at depths of 1,500 to 2,400 feet.

The paper concludes with recommendations as to future development and copies of drillers' logs of wells. R. W. STONE.

GEOLOGY AND HYDROLOGY.—*Ground water in the Norwalk, Suffield, and Glastonbury areas, Connecticut.* HAROLD S. PALMER. U. S. Geol. Surv. Water-Supply Paper 470. Pp. 171, pls. 12, figs. 18. 1920.

This paper is the third to appear of a series of detailed reports on the ground water resources of selected areas in Connecticut The first part of the report is of a general character and treats of the water-bearing formations, occurrence and recovery of ground water, and its quality. This is followed by descriptions of the thirteen towns included in the three areas.

Almost everywhere small quantities of water may be obtained from fissures and joints in the bed rocks which include igneous and metamorphic rocks of pre-Triassic age, and sandstone, shales, and traps of Triassic age. In the upper levels the bed rock is overlain by till which in general yields satisfactory domestic supplies. The deposits of stratified glacial outwash in the lowlands yield abundant supplies of water.

For each of the three areas there is given a geologic map showing the distribution of the various water-bearing formations, and a map showing the distribution of woodlands and the locations of the wells and springs referred to in the tables in the body of the report. H. S. P.

HYDROLOGY.—*Water supply of St. Mary and Milk Rivers, 1898–1917.* B. E. JONES AND R. J. BURLEY. U. S. Geol. Surv. Water-Supply Paper 491. Pp. 583, pls. 26. 1920.

This report is a compilation of all stream-flow data collected in 1898–1917,

at both the international and national stations in the Milk and St. Mary River basins (Montana and Canada). It was prepared under the direction of the United States Geological Survey, the United States Reclamation Service, and the Reclamation Service of Canada. Most of the records assembled appear as originally published in reports of the Reclamation Service of Canada and the United States Geological Survey, but some have been revised. Tables of daily discharge not heretofore published have been taken from the original records. The data presented for each gaging station in the area covered by this report comprise a description of the station, a table giving results of discharge measurements, a table showing the daily discharge of the stream, and a table of monthly and yearly discharge and run-off. Hydrographs are given for 13 stations. N. E. DOWELL.

PALEONTOLOGY.—*American species of* Operculina *and* Heterostegina *and their faunal relations.* JOSEPH A. CUSHMAN. U. S. Geol. Sur. Prof. Paper **128-E**: 125–131, pls. 18–21. 1921.

Before 1915, the presence of nummulites in the upper Eocene limestone of central Florida was thought to distinguish that rock, to which the name Ocala limestone was applied, from the otherwise similar "Peninsula limestone." Latterly, nummulitic Foraminifera have been found at many places in the much wider area in Florida, Georgia, and Alabama throughout which the Ocala limestone as now defined extends.

Besides Heilprin's two species *Nummulites willcoxi* and *N. floridensis*, which are now referred to the closely related genus *Operculina*, Doctor Cushman describes and figures three new species of *Operculina* and one new species and variety of *Heterostegina* from the Ocala limestone. *Nummulites antillea* Cushman, from limestone of the same age as the Ocala in the island of Saint Bartholomew, is referred to *Operculina*. A previously described species of *Heterostegina*, *H. antillea*, comes from the Oligocene of Antigua, St. Croix. and Santo Domingo. C. WYTHE COOKE.

PALEONTOLOGY.—*A new species of* Orthophragmina *from Louisiana.* JOSEPH AUGUSTINE CUSHMAN. U. S. Geol. Sur. Prof. Paper **128-E**: 139, pl. 22. 1921.

This short paper, which is supplementary to the author's "The American Species of Orthophragmina and Lepidocyclina," describes and figures *Orthophragmina advena* Cushman from the St. Maurice formation (lower Claiborne Eocene) of Natchitoches, La. C. WYTHE COOKE.

ORNITHOLOGY.—*Descriptions of apparently new South American birds.* W. E. CLYDE TODD. Proc. Biol. Soc. Wash. **33**: 71–76. 1920.

Study of the material obtained from recent explorations in French Guiana, the lower Amazon, and the Santa Marta region has resulted in the discovery of further new birds which are here described. The three new species are: *Polioptila guianensis*, from French Guiana; *Myrmopagis paraensis*, from Brazil; and *Nyctipolus maculosus*, from French Guiana. The thirteen new subspecies are as follows: *Myospiza aurifrons meridionalis*, from Bolivia; *Brachyspiza capensis argentina*, from Argentina; *Volatinia jacarini atronitens*, from Mexico; *Sublegatus glaber obscurior*, from French Guiana; *Sayornis latirostris fumigatus*, from Colombia; *Sirystes albocinereus subcan-*

escens, from Brazil; *Cercomacra tyrannina laeta*, from Brazil; *Formicarius ruficeps orinocensis*, from Venezuela; *Sclerurus rufigularis fulvigularis*, from French Guiana; *Microxenops milleri guianensis*, from French Guiana; *Furnarius leucopus exilis*, from Colombia; *Dendrocolaptes certhia medius*, from Brazil; and *Veniliornis oleaginus exsul*, from Colombia.

H. C. OBERHOLSER.

ORNITHOLOGY.—*Diagnoses of some new genera of birds*. ROBERT RIDGWAY. Smith. Misc. Coll. 72[4]: 1–4. 1920.

In the course of investigations of North American birds, several new genera have been brought to light and are here characterized. Four of these belong to the Buteonidae, as follows: *Oroaetus*, type, *Falco isidori* Des Murs; *Phaeoaetus*, type, *Falco limnaetus* Horsfield; *Morphnarchus*, type, *Leucopternis princeps* Sclater; and *Percnohierax*, type, *Falco leucorrhous* Quoy and Gaimard. Three others are included in the Rallidae: *Hapalocrex*, type, *Rallus flaviventris* Boddaert; *Limnocrex*, type, *Porzana cinereiceps* Lawrence; and *Thryocrex*, type, *Corethrura rubra* Sclater and Salvin.

H. C. OBERHOLSER.

ORNITHOLOGY.—*Washington region* [*October and November, 1919*]. H. C. OBERHOLSER. Bird Lore 22: 47–48. 1920.

The mild weather of October and November, 1919, apparently induced a large number of birds to remain considerably beyond their former records in the vicinity of Washington. Details are given for a number of species.

H. C. O.

ORNITHOLOGY.—*Federal and State game preserves*. E. W. NELSON. Bull. Amer. Game Protect. Assoc. 9[2]: 6–8. 1920.

Draining of the lakes and marshes is one of the most serious dangers that now threaten our waterfowl. These bodies of water in their original state have as great value as if converted into farm lands, since their annual output of game, fish, and fur-bearing animals will yield as great monetary return as the crops that might be raised on the same land. Furthermore, the presence of such areas throughout the country will have in addition to this monetary return a high recreational value. In many States the preservation of these lands in their original condition is now the most urgent need in wild life protection, particularly in the conservation of wild fowl, since the elimination of their breeding grounds means the disappearance of the birds. More refuges should be established like those already under the jurisdiction of the State and Federal governments. Likewise, public shooting grounds and refuges should be increased in number in the national forests.

H. C. OBERHOLSER

ORNITHOLOGY.—*The crow in its relation to agriculture*. E. R. KALMBACH. U. S. Dept. Agric., Farm. Bull. 1102: 1–20. 1920.

The present report is a resumé of the data and conclusions presented in a prior and more extensive bulletin. From the evidence available it is apparent that the crow, while unfavorably influencing man's interests by its raids on the poultry yard, its depredations on wild birds, and its attacks on crops, is at the same time of important economic assistance by reason of its warfare on insects. It is, therefore, evident that while it would be unwise to give the crow absolute protection, it would be equally unfortunate to adopt a policy of extermination. H. C. OBERHOLSER

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

854TH MEETING

The 854th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium on October 22, 1921. It was called to order at 8:15 p.m. by President FARIS with 45 persons present.

The first paper of the evening, on *Sky brightness and daylight illumination measurements*, was presented by Mr. H. H. KIMBALL, and was illustrated. It was discussed by Mr. HUMPHREYS.

The brightness of the sky has been measured almost daily at the American University, Washington, D. C., between April 5 and July 14, inclusive, and at Chicago, Illinois, between July 19 and August 15, inclusive, 1921.

The illumination from sunlight and skylight combined, and from skylight alone, was measured on a horizontal surface, and also on a surface normal to the incident solar rays; and at Washington, measurements were obtained of the skylight illumination on vertical surfaces facing 0°, 45° 90°, 135°, and 180° in azimuth from the sun.

About half the Chicago measurements were made on top of the dome of the Federal Building, in the Loop district, one of the smokiest sections of the city. The remainder were made at the University of Chicago, which in summer is comparatively free from smoke when the wind blows from the lake. Southeast and southwest winds, however, bring considerable smoke from South Chicago and the Union Stockyards, respectively.

There is little smoke in the atmosphere at the American University, D. C.

A comparison of the Washington and Chicago measurements shows that towards the sun on cloudless days the sky brightness does not differ materially at the two places, but opposite the sun the horizon in Chicago is darkened by smoke, especially in the Loop district.

With a cloudless sky the direct solar illumination at Chicago is noticeably weaker than at Washington. In the Loop district, with the sun not more than 40° above the horizon, it averages only 60 per cent as intense. The illumination on a vertical surface facing 180° in azimuth from the sun, computed from the sky brightness measurements, averages only about two-thirds as intense as the illumination computed from similar measurements for Washington.

A method is given of combining computations of illumination on horizontal and vertical surfaces from sky brightness measurements with determinations of the shading effect of buildings or other objects. This makes it possible to compute for average sky conditions of the various types the illumination that results from exposure to any given portion of the sky at any hour of the day or season of the year.

The second paper, on *The mathematical equations for heat conduction in the fins of air-cooled engines*, by S. R. PARSONS and D. R. HARPER, 3D, was presented by Mr. HARPER. It was discussed by Mr. HAWKESWORTH.

The communication included a very brief historical sketch and a discussion of the assumptions, both physical and geometrical, which must be necessarily made to bring the problem within possibility of solution. Then followed

the development of an expression for approximate fin effectiveness, based upon rather simple mathematics and very convenient in form for engineering use, the essence of this paper being an examination into the magnitude of the errors involved in using this expression without correction, and a determination of the corrections needed for accurate work, a process involving considerable mathematics quite outside the range of usual engine design practice.[1]

855TH MEETING

The 855th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium, November 5, 1921. It was called to order at 8:15 p.m. by President FARIS. 48 persons were present.

The President called attention to the revised By-laws under which officers of the Society are now nominated and elected. The President announced that the Committee on Elections, consisting of Messrs. C. T. RUDE, *Chairman*, C. R. DUVAL, and IRWIN G. PRIEST, was present, and ready to receive nominations in writing for president, two vice-presidents, treasurer, corresponding secretary, and two members of the General Committee.

The first paper of the evening, on *The great tides in the Bay of Fundy, and their causes*, was presented by Mr. H. A. MARMER, and was illustrated. It was discussed by Messrs. CRITTENDEN, PRIEST, L. J. BRIGGS, WHITE, and STIMSON.

In the Bay of Fundy here occurs the greatest known rise and fall of the tide. In the upper part of this bay, in a period of six hours, the tide rises a vertical distance of from 40 to 50 feet, and in the following period of six hours it falls the same distance.

The Bay of Fundy is a funnel-shaped body of water with a gradually shoaling bottom from mouth to head, and it is to these features that the great range of the tide in the upper reaches of the bay has been ascribed, for it is well known that the concentration of the energy of motion of a large mass of water in a narrowing channel brings about an increase in the range of the tide. But this explanation does not account satisfactorily for an increase in the range from less than 10 feet at the mouth to more than 40 feet at the head.

On the southern shore of the bay the range of the tide increases from 9.1 feet at Cape Sable to 44.2 feet in Noel Bay. On the northern shore a similar condition prevails, the range of the tide increasing from mouth to head, and this increase becomes even more striking if one begins with the tide at Nantucket Island and goes up the coasts of Massachusetts, New Hampshire, Maine, and New Brunswick, which form the western and northern shores of the Gulf of Maine and the Bay of Fundy, the mean range at Nantucket being a little more than one foot and at Moncton 41.2 feet.

An examination of the ranges of the tide on the two shores of the bay brings out the fact that on the southern shore the range of the tide is greater than on the northern shore, this difference being due to the deflecting force arising from the rotation of the earth.

From a study of the times of the tide in the bay and of the relation of time of current to time of tide it develops that the tidal movement is of the stationary wave type, with the node at the mouth. In consequence of this

[1] See also the paper by the same authors in this JOURNAL 11: 409–416. October 19, 1921.

there is a gradual increase in the range of the tide from mouth to head. A further increase takes place in the upper reaches of the bay, because of the very considerable contraction in width and shallowing in depth.

By applying the formulas for stationary wave oscillation in a body of water open at one end, as developed by Harris and by Honda and his colleagues, the period of oscillation of the Bay of Fundy is found to approximate $12\,^1/_2$ hours or the period of the ocean tide. It may, therefore, be concluded that the tidal phenomena in the Bay of Fundy arise primarily from the fact that the period of oscillation of the water in the bay closely approximates the period of the ocean tide. This brings about a stationary wave movement of the water with the greatest possible rise and fall for the existing geographic features.

The second paper, on *Characteristic soft X-rays*, by F. L. MOHLER and P. D. FOOTE, was presented by Mr. MOHLER, and was illustrated. It was discussed by Messrs. L. J. BRIGGS, HUMPHREYS, TUCKERMAN, and CRITTENDEN.

The paper has been published in brief form in this JOURNAL.[1]

H. H. KIMBALL, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

The Horological Institute of America was formally organized at the offices of the National Research Council on October 20. One of its important purposes is to aid the jewelry trade in raising the standard of watch repair work, through a system of examination and certification in which samples of repair work on watches will be tested by the Bureau of Standards.

The Petrologists' Club met on November 16 at the home of H. G FERGUSON, and discussed the following papers· C. N. FENNER: *Evidence of assimilation during the Katmai eruption*, N. L BOWEN: *The alnoite rocks near Montreal.*

The non-magnetic ship *Carnegie* of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, arrived at Washington on November 10, completing a two-year cruise around the world. The *Carnegie* left Hampton Roads in October, 1919, and has touched at points in western Africa, Argentina, South Africa, Ceylon, Australia, New Zealand, the southern Pacific islands, and Hawaii, returning by way of the Panama Canal. Capt J. P. AULT was in command, and the rest of the scientific personnel consisted of Messrs. H. F. JOHNSTON, A. THOMSON, H. R. GRUMMANN, R. R. MILLS, R. PEMBERTON, and F. A. FRANKE.

The following educational courses are being given at the Department of Agriculture this winter· (1) H. C. TAYLOR, of the Department: *Agricultural economics;* (2) H. R. TOLLEY: *Statistical methods* (with special lectures by Messrs. MURRAY, ANDREWS, and HOLMES); (3) C. O. APPLEMAN, of the University of Maryland: *Biochemistry;* (4) L. R. JONES, of the National Research Council: *Plant pathology;* (5) B. E. LIVINGSTON, of Johns Hopkins University: *Plant physiology;* (6) SEWALL WRIGHT, of the Bureau of Animal Industry: *Genetics;* (7) W. J. HUMPHREYS, of the Weather Bureau: *Physics of the air;* (8) R. C. TOLMAN, of the Fixed Nitrogen Research Laboratory: *Statistical chemistry.* Special graduate courses are also being ar-

[1] This JOURNAL 11: 273–274. June 19, 1921.

ranged, the first of which is being given by E. T. WHERRY, of the Bureau of Chemistry, on *Advanced crystallography.*

The following Washington scientists have been appointed members of the technical staff of the American delegation to the Conference on the Limitation of Armament: Dr. L. W. AUSTIN, radio specialist of the Navy Department; Dr. J. H. DELLINGER, chief of radio investigations at the Bureau of Standards; Gen. AMOS E. FRIES, chief of the Chemical Warfare Service of the Army; Gen. GEORGE O. SQUIER, chief of the Signal Corps of the Army; Dr. S. W. STRATTON, Director of the Bureau of Standards.

Mr. CARL S. CRAGOE, who has been on a year's leave of absence and engaged in graduate study at Johns Hopkins University, has returned to the Bureau of Standards.

Mr. T. IKEGAMI, chief geologist of the Nippon Oil Company, visited the scientific institutions of Washington in November.

Dr. SYLVANUS G. MORLEY, research associate of the Carnegie Institution of Washington, delivered a public lecture at the auditorium of the Institution on the evening of November 15 on *The chronology of the ancient Maya.*

Miss EUNICE ROCKWOOD OBERLY, since 1908 librarian of the Bureau of Plant Industry, U. S. Department of Agriculture, died suddenly at her home in Washington on November 5, 1921.

Dr. JOHN AUGUSTINE ZAHM, of Holy Cross College, Brookland, D. C., died at Munich, Bavaria, on November 11, 1921, in his seventy-first year. Dr. Zahm was born at New Lexington, Ohio, June 14, 1851. He became a member of the Order of the Holy Cross in 1871, and was in charge of the scientific department of Notre Dame University, Indiana, from 1874 to 1895. He accompanied the late ex-President THEODORE ROOSEVELT on his Brazilian expedition. He was the author of a number of books and papers on evolution and on the geography and history of South America.

Correction: The JOURNAL was in error in stating in a news item, on page 448, that Dr. MERWIN PORTER SNELL, who died on September 23, 1921, was at one time connected with the Smithsonian Institution. He was an employee of the Bureau of Fisheries from 1882 to 1890.

ERRATA

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P. 45	Footnote 4	read L. H. Adams, E. D. Williamson and J. Johnston, Jour. Am. Chem. Soc. 41: 12–42. 1919.
P. 46	Last item in column 4, table 1 should	read −0.02
P. 48	In Equation (5), for +	read ×
P. 151	7th line up from bottom—For x	read x_0
P. 153	Equation (12) for f_0	read F_0
P. 301, line 12 . . .	For discoid	read disciform
P. 378	553rd meeting, for March 21	read March 1

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An * denotes an abstract of a published paper. A † denotes an abstract of a paper presented before the Academy or an affiliated Society. A § indicates an item published under the head Scientific Notes and News.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

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